OPERATIVE SURGERY

VOLUME ONE

OPERATIVE SURGERY

UNDER THE GENERAL EDITORSHIP OF

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VOLUME ONE

INTRODUCTORY
SURGERY OF TRAUMA
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INTRODUCTION

By far the best way of learning how to perform an operation is to watch, or better still assist, an acknow master carry out the procedure on several occasions. Nothing contained in a book can equal a personal appr ship of this kind. Nevertheless it would be odd indeed if this were considered an adequate reason for decryi value of all books on operative surgery Few surgeons faced with the task of performing some operation of they have only limited experience can take the time to watch a colleague skilled in this procedure perfo operation. Yet this same colleague's experiences transmitted, even imperfectly through the medium of a may be a considerable help

However if it is accepted that the best way to learn operative surgery is to *watch* an operation perfect formed, the emphasis in a book on operative surgery must clearly be *visual*

Thus, two important guiding principles have been before us during the compilation of this work. First usual practice of describing an operation in words and illustrating the text with a number of pictures has to us a bad one. We have tried instead to see to it that each operation is described in pictures stage by sta that the text should be very short and used solely for the purpose of clarification and to indicate difficu hazards in the various steps of the operation. Secondly for each operation of any complexity we have in contributor with particular experience and interest in the field concerned.

In the specialist sections we have been advised by our Associate Editors on both the operations to be in and the contributors. The general policy here has been to omit any procedure which ought only to be per in a special centre but to include all operations which a surgeon working on his own in an isolated com might have to perform.

This work is therefore intended for both general and specialist surgeons. It is not envisaged that a surgeo is an expert in any particular technique will seek for advice or to refresh his memory on the way to perfo operation, but it is expected that the same man may well obtain useful information from these volume called upon to operate in an unfamiliar field. In addition it is hoped that the work will be of material postgraduate surgical students, particularly during their training period as surgical registrars

Some general advice upon indications, contra-indications, pre-operative and post-operative treatment, c cations, and the like has been included in the description of each operation, but this too has been outlined for it is intended that this work should be complementary to "British Surgical Practice" in which these and all other details of diagnosis and investigation have been fully covered.

It has necessarily been decided to arrange the material included under regional headings and to en classification based upon operative procedures rather than the diseases they are designed to cure. Any arrangement would have led to much repetition.

Now be it a pneumonectomy or a simple appendicectomy no two surgeons perform the same operatio identical way and sometimes the differences of method are great, though the final result is the same. In n craft does technique vary so much with the individual as in operative surgery It is thus impossible in a te even a very large one to cover every variation of technique In this work contributors have been asked t all common variations but to concentrate upon the technique or techniques which *they* have through exp come to prefer As Editors we have naturally found that this has occasionally meant that an operation h

described which we do not perform or a technique advocated which we do not follow Inevitably we have felt a certain disapproval on these occasions, but as each contributor is a recognized expert we have bowed to his judgment and illustrated the operation as he performs it, fully realizing that many of our readers may feel a similar disapproval if they find that a favourite manoeuvre has been omitted.

In conclusion, we would like to thank our Associate Editors, Contributors and particularly the Artists for the immense amount of work they have put in, and to stress again that the main object of this book is to provide a method by which a surgeon can readily obtain information on how to perform an operation with which he is not fully familiar

CHARLES ROB

June 1956 RODNEY SMITH

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Materials used for ligation of vessels and suture of tissues are of two types, absorbable and non-absorbable. Non-absorbable sutures may be removable or permanent. The choice of material to be used in an operation is governed almost entirely by the technique of the individual surgeon, the only guiding principle being that permanent non-absorbable sutures should not be used in the presence of infection. Suture materials in common use are briefly described and commented upon in the following notes.

Absorbable sutures

Catgut is the only absorbable suture used at the present time (though it may possibly be superseded by synthetic materials in the future). Catgut is prepared from the collagenous sub-mucosal layer of the sheep's intestine. This is stripped from muscle and from mucosa, washed and divided into strands. The strands are then either twisted into cords of plain catgut which is placed in ampoules, sterilized and sealed, or are bathed in chromic acid individually before being twisted into chromic catgut.

Plain catgut is indicated in the ligation of small subcutaneous vessels, or for the placing of subcutaneous fat sutures. It loses its tensile strength rapidly (reputedly being absorbed in 7–10 days) and is not employed for suture of any layers likely to be subject to tension. Recent doubt has been cast on the non-reactive properties which plain catgut has been supposed to possess in distinction to chromic material. Sizes in common use are 4/0 and 2/0.

Chromic catgut was formerly classified by its duration of existence in the tissues (that is 20 day, 30 day). Medium chromic catgut, corresponding to the old 20 day catgut is now almost universally used. Chromic catgut is employed for ligation of vessels and suture of tissues in the presence of established or potential infection. Its absorbability indicates it as the most suitable material for suture of intestine, bladder and peritoneum. In the closure of muscle and fascial layers of a wound, it has the disadvantage of rapidly declining tensile strength, and a tendency for knots to slip. Should it be used for this purpose it is best reinforced by non-absorbable removable sutures.

The tubes of "non-boilable" catgut in common use must be sterilized before use by washing with soap and water or detergents and by immersion for 24 hours in an antiseptic solution such as carbolic 1 in 20, formalin and alcohol, or 70 per cent alcoholic iodine. It is hardly necessary to emphasize that the tubes should always be rinsed thoroughly before being transferred to the instrument table and that they should always be well wrapped in gauze or a towel before opening by any method is attempted.

Sizes of chromic catgut in use range from 2 to 6/0 (a table of knot-breaking strains is appended from the Ethicon sutures handbook). The sizes laid down in the *British Pharmacopoeia* and in the *United States Pharmacopoeia* are equivalent.

Size	*Knot-breaking Strain* (pounds)
6/0	0·65
5/0	1·87
4/0	2·8
3/0	3·7
2/0	5·8
0	7·8
1	10·5
2	12·6

LIGATURE AND SUTURE MATERIALS

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2/0	5·8
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1	10·5
2	12·6

For abdominal surgery including the ligation of vessels, intestinal anastomosis and closure of the peritoneum, size 0 is usually regarded as sufficiently strong In all suturing procedures within the abdomen catgut is best mounted on an atraumatic needle.

Complications

Slipping of a catgut ligature due to the knot uncoiling when slimy from tissue fluid has been seen All major ligatures should be tied with a treble reef or a surgeon s knot.

Gross wound sepsis may result in ultra-rapid dissolution of catgut and in wound disruption Sepsis from catgut knots is not, as a rule due to the gut, but to the foreign body action which it may occasionally provoke giving rise to sinus formation The offending knot, if single may generally be extracted with a crochet hook. Tetanus has in the past been introduced by catgut sutures, but there is no recent record of this untoward event.

Non absorbable sutures

Silk

Silk is classed as non-absorbable although a gradual absorption and replacement with fibrous tissue does in fact take place during a period of 2 years from the date of insertion.

The three varieties of surgical silk are braided, twist and floss. These may be untreated, or waterproofed, and are usually packed in unsterilized spools. Meticulous sterilization before use is essential, and this is best accomplished by autoclaving after winding on to bobbins or metal galleries, and sealing in labelled envelopes. Sterilization by boiling for 20 minutes is acceptable in conditions of emergency

Silk is an excellent suture material when used with careful asepsis in clean wounds. It has a high tensile strength for its diameter handles and knots well, and is not subject to slipping unless heavily waxed. In general surgery it is pre-eminently suitable for the interrupted serous layer of an anastomosis, for ligation of vessels, and for closure of the fascial layers of a wound. It has well withstood the test of time in the repair of inguinal hernia, when its gradual absorption and replacement by solid fibrous tissue render it particularly valuable.

As a removable suture material, waterproofed silk is eminently suitable for suture of skin and for the placement of tension stitches there would seem little doubt that waterproofing diminishes the incidence of minor inflammatory stitch reactions.

Braided silk is now in much more general service than twist. It is conveniently used in a black dyed form The British size scale which is frequently used and quoted, ranging from 2/0 to 16 is not equivalent to *British Pharmacopoeia* catgut grading and many surgeons find it more satisfactory to employ the catgut scale for silk also (*see* Table page 8) The breaking strains given below are equal to half the tensile strength by straight pull.

Size	*Knot-breaking Strain* (pounds)
5/0	0·5
4/0	1·0
3/0	1·5
2/0	2·5
0	3·5
1	5·0
2	6·5
3	8·0
4	10·0

A tensiometer applied to sutures as used in medical procedures has, however shown that the effective strength of an interrupted silk suture is over twice the *B.P.C.* knot strength, and that a continuous suture may be up to ten times the *B.P.C.* knot strength (Douglas, 1949)

Sizes 5/0 and 4/0 silks mounted on an atraumatic needle are used in the finest plastic procedures. Sizes 3/0 and 2/0 are adequate for normal skin suture and the ligation of smaller vessels. Size 0 may safely be employed for the closure of the fascial layer of an abdominal wound. Sizes 1 and 2 are indicated for the ligation of major vessels and the insertion of tension stitches. For the ligation of haemorrhoids size 4 or larger is preferred

Floss silk is chosen by many surgeons for hernial repair Its successful use demands the most meticulous attention to details of technique haemostasis and asepsis, and it is preferably used from a factory-sterilized ampoule

Complications.—The chief disadvantage of silk lies in its tendency to perpetuate any minor wound infection as an infected foreign body In any situation, therefore in which a reasonable asepsis cannot be guaranteed non-removable silk should be avoided. When inflammation occurs in a wound containing silk, no time should be wasted in abortive chemotherapy The offending sutures must be removed, even if this entails a re-opening of the wound.

Linen and cotton

These materials are prepared in the same manner as silk, and the indication for their use is essentially the same. To many operators linen and cotton do not seem to handle quite as well as silk and have at times proved unpredictable in their knotting strengths. Those accustomed to them, however extol their virtues and economy They have their own scale of sizes from 80 up to 12 (*see* Table, page 8)

Nylon

Braided and monofilament nylons have been brought into prominence as suture materials in recent years. Nylon is supplied on spools, sterilized by autoclaving and packed in the 6/0 to 4 scale employed for catgut or silk. An alternative scale for monofilament nylon ascending in size from 1N to 8N exists. The breaking strains of nylon are very slightly higher than silk of equivalent diameter Nylon is used for the same purposes as silk but would seem to have few advantages over the older material Although non-reactive in a non-infected wound, it is completely unabsorbable Monofilament nylon, originally hailed as the ideal material for the repair of hernia, and for the continuous closure of the rectus sheath, has given many surgeons cause for dissatisfaction. It must be knotted by a double surgeon s knot as a minimum and its tensile strength in the knot itself is capricious if this is tightly tied. Fragmentation and intra-abdominal and extra-abdominal extrusion have been observed even in non-inflamed soundly healed wounds, necessitating the removal of the entire suture. Stout nylon is, however an excellent removable tension suture, and has largely replaced silkworm gut for this purpose.

Nylon and Orlon cloth, Terylene (Dacron) (Deterling and Bhonslay 1955) and Polyvinyl alcohol sponge (Schofield, 1955) have all recently given promising results in the repair of large connective tissue defects, and in the provision of scaffolding for bridging specialized tissues. Though full evaluation must await the passage of time, the use of these materials would seem well established.

Silkworm gut and horsehair

These once-popular removable sutures are not now used to any great extent, chiefly owing to lack of standardized diameters and strengths, and difficulty in sources of supply

Wire

Stainless steel and tantalum wire are graded by the Imperial standard wire gauge. Sterilization is by autoclaving or boiling

Tantalum wire is employed in its finest sizes on an atraumatic needle, for nerve suture by virtue of its non-reactive nature. The medium sizes of steel wire have proved of service in tendon repair and transplantation, the sutures being of the removable pull-out type elaborated by Bunnell. As a non-removable suture for the abdominal wall steel wire has proved a disappointment. It fragments rapidly the points of the broken portions either extruding or giving rise to pain.

Tantalum gauze as a repairing material for hernial defects is also subject to the same disadvantage.

In orthopaedic procedures stouter wire is used, and in this branch of surgery it is important that wire used in conjunction with other metallic devices should possess the same composition Molybdenum steel is preferred by many operators.

Silver wire is now seldom used on account of its poor tensile properties. It is still the most suitable material for the Thiersch repair of rectal prolapse (20 I.S W G) though fragmentation is frequent, and rewiring sometimes necessary

Other materials

In conclusion, an extensive variety of materials have been and are still used in the repair of inguinal hernia they include fascia lata, skin kangaroo tendon and the individual protagonists of these substances achieve good results

from them. It is wise for the general surgeon to use only those materials which have withstood the test of time and widespread employment, in the uses of which he has been well trained, and having properties and behaviour with which he is well acquainted.

Equivalents

A Table is appended showing the approximate equivalents of various suture materials. The diversity of scales employed constitutes a constant minor inconvenience to theatre staff, instrument suppliers and curators and to surgeons and it is to be hoped that some degree of uniform scale will in the future, be adopted.

COMPARISON OF SIZES OF SUTURE MATERIALS

(Equivalents are only approximate)

CATGUT			*NON-CATGUT*					
B.P. and U.S.P. Sizes	*B.P. and U.S.P. Diameter Range (ins.)*	*U.S.P. Diameter (ins.)*	*British Plaited Silk Size*	*British Twist Silk Size*	*Linen Size*	*Nylon Mono-Filament*	*Nylon Braided (B)*	*I.S.W.G.*
6/0	0 0025–0-0045	0-002-0-004	—	—	—	—	—	—
5/0	0 0045–0-0070	0-004-0-006	2/0	4/0	—	1 (N)	—	38
4/0	0 0070–0-0095	0 006–0-008	0	3/0 2/0	—	2 (N)	1	36
3/0	0-0095–0-0125	0-008–0 010	1	0	80	3 (N)	2	34
2/0	0 0125–0 0160	0-010–0 013	2	1	60	4 (N) 5 (N)	3	32 30
0	0-0160–0-0195	0-013-0-016	3	2	40	6 (N)	4½ 5	28
1	0-0195–0 0230	0-016-0 019	4	3	25	7 (N) 8 (N)	6	26
2	0-0230–0-0265	0-019-0-022	5 6	4	18	—	12	25 24
3	0 0265–0-0300	0-022–0 025	7 8 9	5	14	—	—	23
4	0-0300–0-0340	0.025–0-028	10 11	6	—	—	—	22

(By courtesy of Messrs. Allen and Hanbury and Ethicon Sutures)

References

Deterling, R. A., and Bhonslay, S. B. (1955) *Surgery* **38**, 71
Douglas, D. M. (1949). *Lancet*, **2**, 497
Schofield, T. L. (1955) *Brit. J. Surg.* **42**, 618.

LOCAL ANAESTHESIA—TECHNIQUE

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LOCAL AND REGIONAL BLOCK

General principles

Nerve block gives excellent operating conditions with analgesia from 1 to 8 hours duration combined with muscular relaxation and a bloodless field. It is desirable that the patient be kept asleep during major surgery unless his life is endangered thereby The advantage of the nerve block over the relaxant technique is in the diminished haemorrhage either due to local ischaemia when adrenaline is used in the analgesic, or to generalized hypotension induced by paravertebral, splanchnic, epidural, or spinal block.

Indications

Nerve block is indicated when surgical intervention is required for patients with acute pulmonary conditions such as pneumonia, bronchitis, or status asthmaticus. The method may also be used in cases of bronchiectasis, chronic bronchitis, and emphysema, or in obstructed hernia with vomiting Nerve block may also be used to alleviate pain in fractured ribs, herpes zoster malignant disease, and in the reduction of fractures. It also enables the sitting posture to be used for excision of a portion of rib in a patient with empyema complicated by bronchial fistula.

Drugs

Lack of toxicity rapidity of onset of analgesia, duration of action in relation to the operation contemplated, and convenience, are all factors which recommend a local analgesic. Drugs may be comparatively short acting like procaine long acting like nupercaine or medium acting like amethocaine hydrochloride and lignocaine (Xylocaine)

Adrenaline can be added to the analgesic drug to prolong its action, to combat its vaso-dilatation action, and even to produce ischaemia. Macintosh recommends that not more than 0 5 ml. of 1 in 1 000 adrenaline be injected with the analgesic, but Gabriel recommends the addition of 1 ml. of 1 in 1 000 adrenaline to 2 ounces of 2 per cent procaine for inferior haemorrhoidal block There should not be any serious reaction with this technique. No injection should ever be made without first aspirating to confirm that the needle point is not in a blood vessel and if the needle be moved during injection there should be continuous pressure on the piston so as to lessen the likelihood of puncturing a vessel

Under no circumstances should 1 in 1,000 adrenaline be poured into a gallipot. Patients have died as a result of adrenaline having been injected in mistake for the analgesic. Adrenaline should only be added from an ampoule of 1·0 ml. or 0 5 ml. which has been freshly provided for that purpose.

Toxicity

Some drugs are more toxic than others, but it is the relative toxicity which is important. Nupercaine dose for dose is more toxic than procaine, yet the former is effective as an analgesic in such dilution that its relative toxicity in use is less than that of the latter The toxicity of a drug varies also with the site of the injection as well as the strength used. Absorption is quicker from intramuscular injection than from subcutaneous areas. Likewise absorption from the neck is quicker than from below the clavicles because of the more generous blood supply The addition of adrenaline delays absorption Finally there is always individual idiosyncrasy to the drug used and for this reason a trial injection may be worth while

The reaction to drug sensitivity can be so severe as to cause respiratory failure and cardio-vascular collapse. Early raising of the blood pressure is essential as well as controlled respiration to counteract anoxia. Methylamphetamine (Methedrine) 15–30 mg. intravenously followed possibly by a noradrenaline intravenous drip 1 in 500,000 will prove of the utmost benefit. The immediate treatment of cardio-vascular collapse is essential and life saving.

Sterilization

All syringes, needles, swabs, towels and gallipots should be autoclaved in one special glove tin for convenience. Lignocaine ampoules can be autoclaved repeatedly without deterioration. Nupercaine ampoules may be treated similarly—certainly for three times without deterioration. Amethocaine crystals and procaine powder in ampoules can be sterilized in formalin vapour. Drugs which are to be used for subdural (spinal) block should never be kept in spirit, carbolic, or formalin vapour as minute cracks might lead to chemical contamination and possibly serious neurological sequelae. All ampoules used for spinal analgesia should be autoclaved, and for this reason should be capable of withstanding the temperature without risk of decomposition.

Dosage

On the basis that the toxicity of a local anaesthetic increases out of all proportion to the strength of the solution, 100 ml. of 1 per cent procaine is equivalent to 25 ml. of 2 per cent procaine. It is preferable to consider 1 g. of procaine as the normal maximum dose, but this has been exceeded on occasion.

The following figures act as a good guide to maximum dosage for a healthy adult:

Procaine. 1 g.

Lignocaine (Xylocaine). 0.5 g.

Cinchocaine (Nupercaine). Maximum dose depends on concentration of solution which should not exceed 2 mg. per kg. (that is 190 ml. of 1 in 1 000 solution for a 10 stone patient).

Amethocaine. Maximum dose is 800 mg. or 2 mg. per pound of bodyweight. The writer has certainly used 200 mg. of amethocaine many times with success, but he has seen fibrillary facial twitching after 800 mg. of amethocaine. A small dose of thiopentone easily controls this, but the warning was noted and subsequent injections never exceeded 200 mg.

Premedication

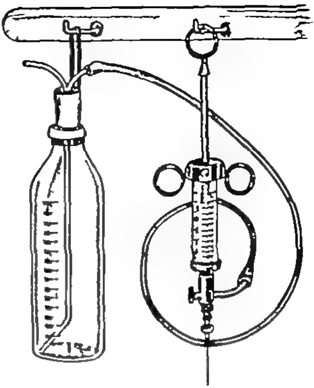
Premedication should always be adequate except in the case of desperately ill or shocked patients, when the drugs should be given intravenously with great caution. The writer favours papaveretum $\frac{1}{3}$ gr. and scopolamine $\frac{1}{150}$ gr. hypodermically 45–60 minutes pre-operatively for an average adult. If the sedation is not sufficient when the patient comes to the anaesthetic room, pethidine 50 mg. may be given intravenously in 10 mg. increments over a period of 5–7 minutes. A careful watch must be kept on the respiration rate and amplitude during injection.

The following technique may be used. One hour before operation the patient is given pethidine 100 mg. and scopolamine gr. hypodermically. On arrival in the anaesthetic room he receives chlorpromazine (Largactil) 12.5 mg., promethazine (Phenergan) 25 mg. and pethidine 25 mg. intravenously. This may be followed by thiopentone 250 mg. intravenously. Patients receiving this usually remain asleep, breathing quietly and adequately throughout the operation, but nitrous oxide and oxygen may be given as well if desired. With this technique the patient has no memory of the actual local or regional block. The small dose of chlorpromazine ensures that the patient wakens quickly and does not lie inert for hours.

Site of nerve block

Nerve block may be regional or local. The latter postulates the injection of analgesic solution at the site of the operation, while the former constitutes a block of the nerves supplying the area. This may be performed in the case of abdominal block as a spinal (subarachnoid) block, epidural, paravertebral, posterior intercostal, mid-axillary line intercostal block, or subcostal abdominal field block. Each one of these methods has advantages and hazards. For example, spinal, epidural and paravertebral block if carried up to the fifth dorsal segment, will cause a marked fall of systolic blood pressure, whereas intercostal block does not affect the blood pressure but in this technique there is a possibility of pleural and even lung damage.

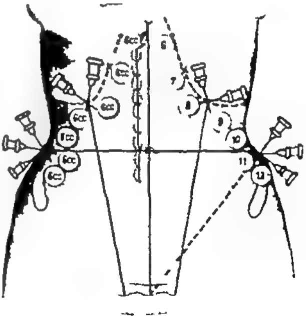
ABDOMINAL FIELD BLOCK



Technique

1 Take 200 ml. of 0.5 per cent procaine add 200 mg. amethocaine hydrochloride 0.5 ml. of 1 in 1 000 adrenaline and 1 000 Benger units of hyaluronidase if desired. Relaxation is complete in 8–10 minutes and lasts 2–2½ hours. The patient assumes a dorsal decubitus position with the arms held abducted during infiltration. The aim is to block the nerves D.6–12 inclusive as they enter the abdomen. D.6 7 8 and 9 reach the abdomen from under the costal margin and proceed between the internal oblique and transversus abdominis muscles. The tenth, eleventh and twelfth dorsal nerves are blocked by the "arrowhead" injection in the loin in the mid-axillary line. Wheals are raised (1) either side of the ensiform cartilage, (2) at a point midway between the ensiform and the linea semilunaris about ½–1 inch below the costal margin and (3) similarly at the tip of the ninth costal cartilage. A 2-inch needle is advanced directly through the skin anterior rectus fascia and down to the posterior rectus sheath and 5–6 ml. of solution deposited in this position while withdrawing the needle slowly.

2 The needle is halted in the subcutaneous tissue of the second and third wheals (seventh and ninth nerves) and two further injections given at 45 degrees parallel with the costal margin. The arrowhead injection is performed, inserting the 2-inch or 2½ inch needle horizontally in the mid axillary line at the level of the umbilicus 6–10 ml. may be injected here. The needle is withdrawn and redirected in the horizontal plane towards the ensiform cartilage and 6–10 ml. are injected. Lastly the needle is again withdrawn and re-directed in the horizontal plane towards the symphysis pubis and another 6–10 ml. of solution are injected.

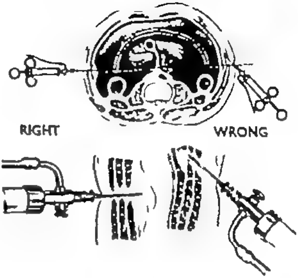


Indications

Where abdominal relaxation is required without intercostal impairment or fall of blood pressure, and where there will be no traction on viscera.

Hazards

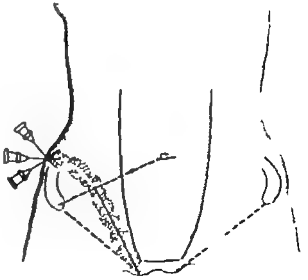
3 Using a reasonable needle 2 inches long and keeping a steady injection whilst advancing the needle the risk of perforating the bowel is negligible. The peritoneum is fairly mobile in the centre of the abdomen and considerably so in the flanks. Care must be taken not to break the needle against the iliac crest when advancing in the direction of the pubis. Subcutaneous infiltration of the line of the incision is not necessary unless ischaemia is required.



MODIFIED INFILTRATION FOR SPECIAL OPERATIONS

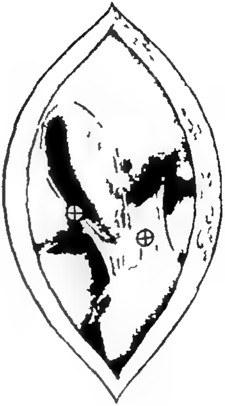
Appendicectomy through gridiron (or left inguinal colostomy)

4 The arrowhead block is performed following infiltration of the line of incision. When the appendix has been gently delivered, the meso-appendix should be infiltrated before clips are applied or the patient will feel pain.



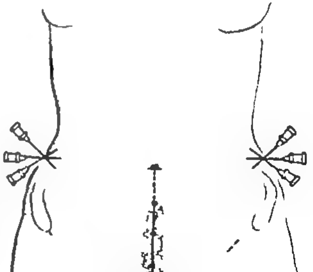
Cholecystectomy

5 The gall bladder is gently exposed and Hartmann's pouch defined. The gall bladder bed is infiltrated subperitoneally with 10 ml. of solution at the reflection of the hepatic peritoneum on to the gall bladder as near as possible to Hartmann's pouch. Further traction is made on the gall bladder and adhesions between it and the duodenum are divided until the free edge of the gastro-hepatic omentum is seen. An injection of 10 ml of solution is made subperitoneally above the duodenum. This tracks around the common bile duct and completes the block. Some form of light narcosis is required during this manoeuvre.



Supra pubic cystostomy

6 Supra-pubic cystostomy may be quite satisfactorily performed under local analgesia by infiltrating the skin and subcutaneous tissues with 2 per cent procaine, or 0·5–1 per cent lignocaine, from just below the umbilicus to the pubes. The rectus sheath may be infiltrated after the skin incision has been made, and when the bladder has been exposed a little analgesic may be injected into the musculature along the line chosen for its incision. On the other hand two "arrowhead" injections on either side may be made to anaesthetize the tenth, eleventh and twelfth dorsal nerves, and this may be followed by a subcutaneous midline injection in the area of incision. It is advisable to put a little analgesic into the bladder wall also. This second method relaxes the lower rectus muscles from the outset.

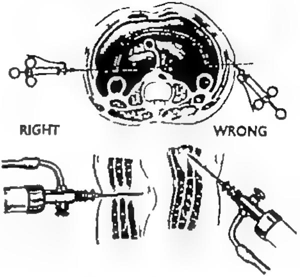


Indications

Where abdominal relaxation is required without intercostal impairment or fall of blood pressure, and where there will be no traction on viscera

Hazards

3 Using a reasonable needle 8 inches long and keeping a steady injection whilst advancing the needle, the risk of perforating the bowel is negligible. The peritoneum is fairly mobile in the centre of the abdomen and considerably so in the flanks. Care must be taken not to break the needle against the iliac crest when advancing in the direction of the pubis. Subcutaneous infiltration of the line of the incision is not necessary unless ischaemia is required.



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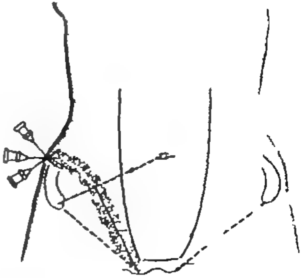

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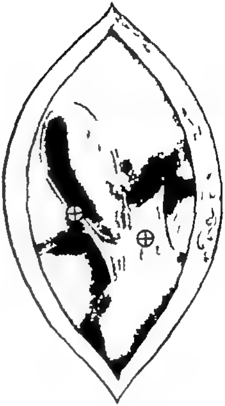
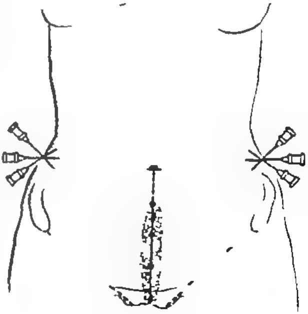


Supra pubic cystostomy

6 Supra-pubic cystostomy may be quite satisfactorily performed under local analgesia by infiltrating the skin and subcutaneous tissues with 2 per cent procaine, or 0.5–1 per cent lignocaine, from just below the umbilicus to the pubes. The rectus sheath may be infiltrated after the skin incision has been made and when the bladder has been exposed a little analgesic may be injected into the musculature along the line chosen for its incision. On the other hand two "arrowhead" injections on either side may be made to anaesthetize the tenth, eleventh and twelfth dorsal nerves, and this may be followed by a subcutaneous midline injection in the area of incision. It is advisable to put a little analgesic into the bladder wall also. This second method relaxes the lower rectus muscles from the outset.

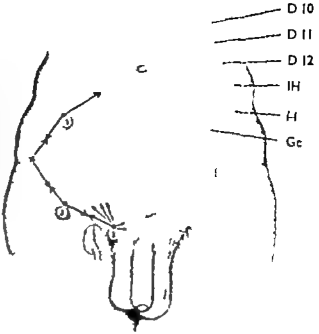


Herniorrhaphy

7 For herniorrhaphy it is necessary to block the ilio-inguinal and ilio-hypogastric nerves by means of an iliac crest block. This is done by forming a skin wheal two fingers breadth (or 1½ inches) on a line from the anterior superior iliac spine to the ensiform. The writer injects 10 ml. of solution directly at right angles to the skin through the muscles of the abdominal wall, using a 2 inch needle. Injection is made continuously. The direction of the needle is then changed to 45 degrees in the direction of the umbilicus and 5–6 ml. are injected. The needle is directed lastly towards the under surface of the iliac crest at an angle of 45 degrees to the original and a further 5–6 ml. injected.

Another method recommended by Macintosh is to inject almost horizontally to strike the inner surface of ilium just below the crest. 10 ml. of an analgesic are injected as the needle is withdrawn. The needle is then inserted at a slightly steeper angle and the same amount is injected. Lastly the needle is passed subcutaneously to the outer edge of the iliac crest and a further 10 ml. are injected on slow withdrawal. These manoeuvres block the ilio-inguinal, ilio-hypogastric and twelfth dorsal nerves but it is important to block the genito-femoral nerve as it enters the internal inguinal

8 ring. Pass a 2-inch needle at right angles to the skin through a wheal raised at mid-inguinal point so that it pierces the fascia of the external oblique. Advance the needle another 2–3 cm. towards the internal inguinal ring. Macintosh recommends that 10 ml. of solution be injected at this point, and after withdrawing the needle 2 cm. a further 10 ml. are injected. This anaesthetizes the neck of the sac, the spermatic cord and the genital branch of the genito-femoral nerve. If the incision is to approach the midline a small amount (5 ml.) should be injected subcutaneously to block the overlap innervation from the other side.



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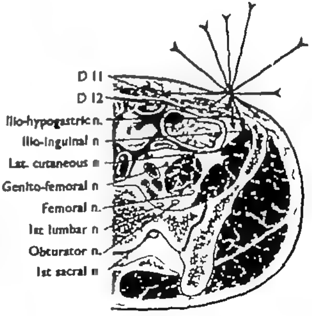

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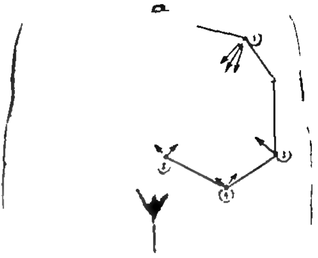


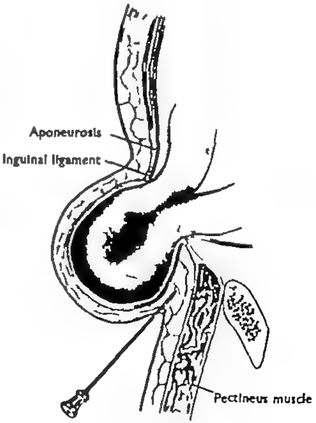
(After Labat)

Femoral hernia

In addition to the infiltration as for an inguinal hernia, the analgesia is needed below Poupart's ligament around the fundus and neck of the sac external to the pubic spine and especially round the inferior surface of the neck. If the Lothiessen approach through the inguinal canal is to be used, the neck of the sac may be infiltrated after the transversalis fascia on the posterior wall of the inguinal canal above Poupart's and Gimbernat's ligament. The bladder is sensitive to touch and may be adherent therefore it should be injected freely with analgesic.

9 Labat's technique of making injections across the abdominal wall, along the line (1) and at the internal inguinal ring in the direction of the arrows, can be recommended. The pubis and obturator nerves are blocked from (2) and Poupart's ligament from (3)

10 The needle is then passed through (4) beneath the hernia and its coverings, towards the neck of the sac. This will require a generous quantity of solution and it is recommended that procaine 0.5 per cent with amethocaine 1 in 2,000 be used, together with 1 in 250,000 adrenaline and 1 000 Benger units of hyaluronidase.



INTERCOSTAL BLOCK

Indications

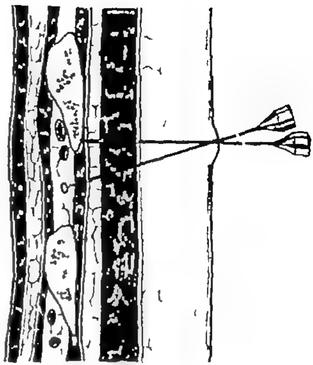
11 Intercostal block is indicated for rib resection and abdominal section. Posterior intercostal block at the angle of the rib will interfere with thoracic movement, whereas block in the mid-axillary line does not do so. For this the patient should be supine with arm abducted to a right angle. For block at the angle of the rib, the patient should be on his side with the arm held well forward to keep the scapula out of the way. Very adequate premedication is required in either technique. Amethocaine 1 in 1 000 or lignocaine, 0·5–1·0 per cent, with adrenaline 1 in 250 000 are the agents of choice.

Technique

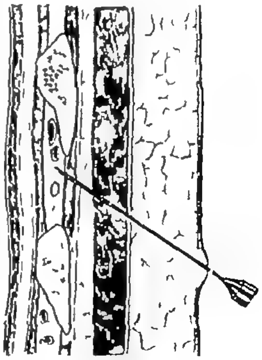
12 The twelfth rib should be identified and a skin wheal raised over it; then skin wheals should be raised over the requisite ribs. With a 2-inch needle fitted with a rubber marker the lower border of the rib is the site to which the point is directed. When the point touches bone the marker is brought within 0·5 cm. of the skin. The needle is then directed downwards to slide over the lower border of the rib until the marker is flush with the skin. After aspiration, if no blood returns, 5–10 ml. of solution are injected. It is well to use 2 needles, inserting the second before removing the first, for it is possible to omit one space altogether. Before advancing the needle to its injection position the syringe should be attached, so that if the pleura should be pierced inadvertently air will not enter. *Under no circumstances* should the needle be moved back and forth during injection as damage may be caused to the lung and a tension pneumothorax develop.

Hazards

The lung may be damaged with resultant tension pneumothorax; even empyema may develop. "Pleural shock" may follow intrapleural injection. Repeated punctures are not well tolerated and the technique takes time to perform.



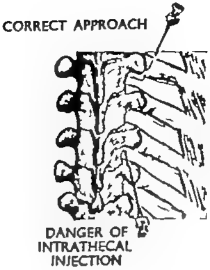
CORRECT METHOD



INCORRECT METHOD

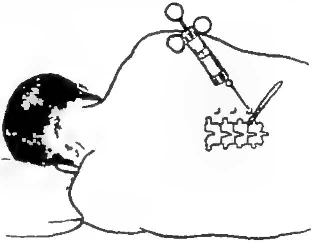
THORACIC PARA-VERTEBRAL BLOCK

13 The region immediately external to the inter-vertebral foramen is known as the para vertebral space. Here each thoracic nerve divides into an anterior and posterior primary division the posterior supplying the back muscles and the anterior passing on between the ribs beneath the internal intercostal muscle after giving off a ramus communicans to the sympathetic ganglion.



Indications

The indications for thoracic paravertebral block are thoracoplasty operations on the chest wall, upper abdominal section, therapeutic block in herpes zoster coronary thrombosis, and fractured ribs.

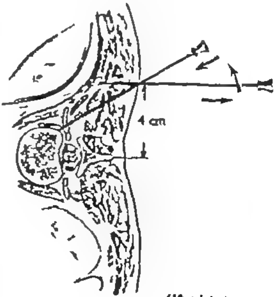


(After Labat)

Technique

14 The patient is placed in a lateral or semi-prone position Owing to overlap, the vertebral spines do not correspond to the body of the vertebra immediately underneath. Identify the twelfth rib and spine of the twelfth dorsal vertebra and from these mark out the area for

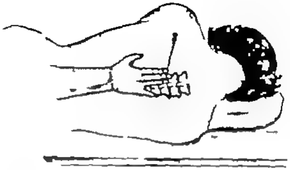
15 analgesia. A line is drawn 4 cm. from and parallel with the midline. Skin wheals are raised on this line over the ribs, and an 8-cm. or 2½–3-inch needle, fitted with a rubber marker is passed through the skin at right angles until the rib is felt. Then the marker is pushed to within 1 cm. of the skin and having slightly withdrawn the needle it is reinserted downward, forward and inward to pass under the rib Here it may be felt to slide along the side of the vertebra. When the marker is flush with the skin, the syringe is attached and the area aspirated to ensure that the needle has not entered a prolongation of the subarachnoid space. If no cerebrospinal fluid or blood is aspirated, 0–10 ml. of an analgesic solution is injected. This procedure is performed in each paravertebral space.



(After Labat)

Alternative method

16 Macintosh and Bryce Smith recommend a slightly different approach. A 10 cm. needle is introduced at 45 degrees 3-fingers breadth from the midline. The needle either strikes the rib or comes up against the body of the vertebra in the true paravertebral space where 5 ml. of solution are injected. The needle is then slowly withdrawn 1 cm. and during this time another 5 ml. of solution are injected.

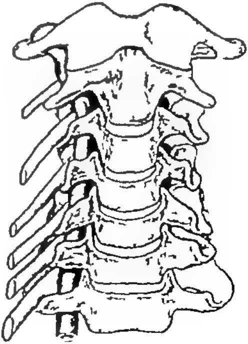


Hazards

Tapping of subarachnoid space is a possibility and the chance of blood-vessel and pleural puncture should also be foreseen For analgesia of the first three dorsal segments a cervical plexus block is necessary as well, owing to innervation overlap Paravertebral block if carried up to D.5 will cause a profound fall of systolic blood pressure, but no splanchnic block will be required as would be the case with abdominal or intercostal block. Owing to the structure of the intervertebral foramen, solution sometimes seeps *via* the epidural space to anaesthetize adjacent nerves.

CERVICAL BLOCK

17 The sensory nerve supply to the neck is mainly from the first four cervical nerves, the anterior primary divisions of which communicate and form the cervical plexus. The first cervical nerve does not divide but the second, third, and fourth each divide to form an ascending and descending branch, which forms a series of loops close to the transverse processes of the first four cervical vertebra under cover of the sterno-mastoid muscle. It is to be noted that they all communicate with the sympathetic chain This plexus gives off superficial cervical branches which pass anteriorly from under the middle of the posterior border of the sterno-mastoid. If the superficial branches only need to be anaesthetized they can be blocked by subfascial and subcutaneous injections along the posterior border of the sterno-mastoid muscle



Lateral technique

18 The patient is put in dorsal decubitus with head to opposite side.
A line joining the tip of the mastoid process to Chassaignac's tubercle is made with an iodine swab. The upper margin of thyroid cartilage is produced back to join the first line. At this point a wheal is raised and another one above this on the line one finger's breadth below the tip of the mastoid process. A further wheal is raised above Chassaignac's tubercle.

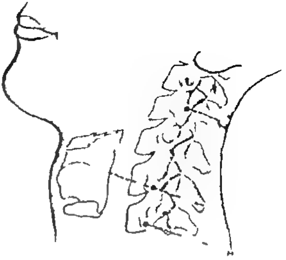
1. Lesser occipital n.
2. Great auricular n.
3. Ant. cutaneous n.
4. Accessory nerve
5. Supraclavicular ns.

(After Labat)

19 The injection is made through 1 and 3 which corresponds to C.2 and C.5 respectively. The needle is introduced through each of these two wheals transversely until the point is felt at the transverse process. The fingers of the left hand are employed palpating the transverse processes. A 2-inch needle is inserted through wheal No. 3 and is advanced towards the tip of the fourth cervical transverse process. The syringe is connected and when the bone is

(After Labat)

20 felt, 3–4 ml. of 1 per cent procaine or 1 in 1 000 amethocaine are injected after aspiration test. As the syringe and needle are slowly withdrawn, a further 4 or 5 ml. are injected The needle is then reinserted at the same spot but is directed to the next transverse process above, when the same procedure is enacted. The second transverse process is not easily palpated but a good guide is the depth of advancement required for the lower injections.

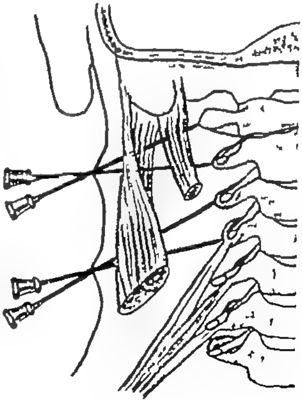


(After Labat)

Hazards

21 Care must be observed not to allow the advancing needle to pass between or in front of the transverse processes, for there is risk of puncturing the carotid artery internal jugular vein and vertebral vessels. It is also possible to puncture the dura mater Labat states that there is no risk to the phrenic or vagus nerves using 1 per cent procaine and that, although there may be paresis of the diaphragm he has never seen paralysis of the muscle or respiratory distress.

Labat recommends placing some 15 ml. of solution subcutaneously and subfascially at the posterior border of the sterno-mastoid. He states the quantity injected seldom exceeds 30 ml. for the deep injections and 20 ml. for the superficial infiltration, making a total of 100 ml. for a bilateral block.



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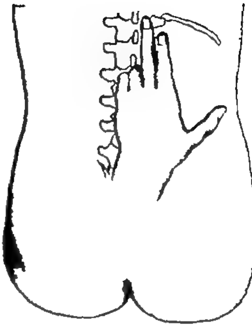
LUMBAR PARA-VERTEBRAL BLOCK

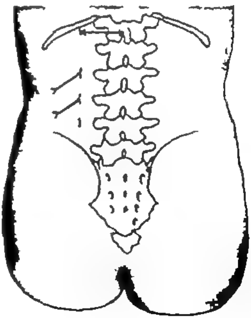


Indications

This block is used to cause vasodilatation of the legs for both therapeutic and diagnostic reasons. It is used in conjunction with dorsal paravertebral block for operations on the kidney and abdomen. If used for operations on the legs, it is necessary to perform a sacral block also.

Technique

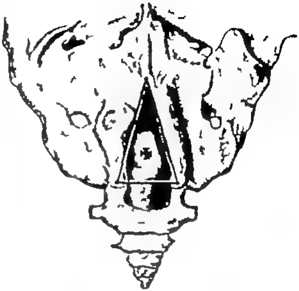
22 The patient is placed in a lateral position, legs drawn well up and head flexed. A small pillow should be under the loin. Skin wheals are raised 5 cm. from the midline, opposite the superior edge of the lumbar spines required (a line 5 cm. long dropped from the twelfth rib marks spine of D.12). A needle 10 cm. long with a rubber marker is advanced through the skin wheal at right angles to the skin until it touches the transverse process. The marker is moved down the needle to within 3 cm. of the skin surface. The needle is partially withdrawn and reinserted inwards
23 and upwards at 25 degrees. The needle point slides over the transverse process, enters the psoas muscle and should be stopped as soon as the marker touches the skin. After aspiration proves negative, 5–10 ml. of analgesic solution are injected. To block the fifth lumbar nerve the needle is directed below the transverse process of the fourth lumbar vertebra for the same distance inwards and downwards.



CAUDAL BLOCK

Anatomy

24 In 84 per cent of sacra the hiatus is triangular and the apex is formed by the spine of the *fourth sacral vertebra, but in 10 per cent the* hiatus is nearer the coccyx owing to fusion of the arches of the fifth sacral vertebra and is much smaller in size. The hiatus is displaced upwards in 47 per cent owing to non-union of the fourth, third—or even second vertebra. In 0 8 per cent the bony wall is completely absent. The dura mater ends at the lower border of the second sacral vertebra in the majority of cases and consequently there is some risk of puncture in using this method. The average distance between hiatus and dura is 47 mm. but the extremes are given as 75 mm. and 19 mm. respectively—therefore, it is usually recommended that the needle be passed through the hiatus for a distance of 20 mm. The volume of the sacral canal varies from 12 ml. to 65 ml.



(After Labat)

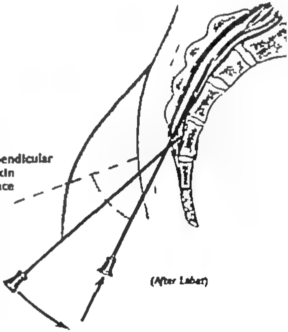
Indications

Caudal block is indicated for operative procedures involving the perineum, urethra and bladder. For childbirth continuous caudal block is used.

Technique

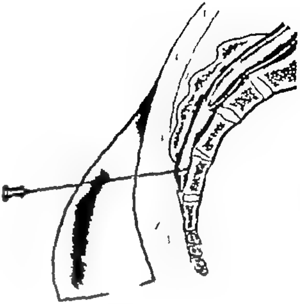
25 The patient may be in the left lateral position with thighs and knees well flexed, or may be in the knee-elbow position with the abdomen supported by several pillows.

The sacral cornua are first identified. A rough guide to these is to place the tip of the middle finger of the left hand upon the tip of the coccyx laying the finger against the skin in the midline. The first interphalangeal joint should lie over the sacral cornua. A skin wheal is made and through this is passed a needle cannula (Dawkins or Hingson s) through the fibrous roof of the hiatus. The needle is then depressed some 20 degrees towards the natal cleft and at the same time it is pushed along the canal.



(After Labat)

26 After advancing for 15 mm the needle is withdrawn leaving the cannula in position. After an aspiration test, 8 ml. of solution are injected. Within 5 minutes or so it will be possible to ascertain that there has been no hidden puncture of the dura with resulting spinal analgesia. If there is no analgesia of the legs (indicating spinal block) a further 22 ml. may be injected. This will give analgesia of the perineum and in some instances, there will be an area of analgesia extending for 5 cm. above the symphysis pubis.



Alternative technique

In this instance, a short needle (No. 1) which is stiff and 1–1½ inches long, is passed through the fibrous roof of the hiatus and is felt to impinge on the bone beneath. It is possible to inject without changing the position or direction of the needle and there is no risk of dural puncture. The solution should flow easily and freely. If it does not do so the needle is not rightly placed.

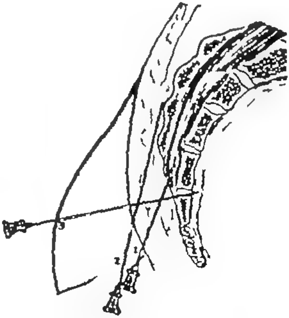
This technique was suggested by Dr James Rochford, and it has been used as a routine by the author with very satisfactory results.

Drugs

The author recommends lignocaine (Xylocaine) 1·5 per cent or a mixture consisting of equal parts of 2 per cent lignocaine and 1 in 600 cinchocaine (Nupercaine). Thirty ml. of the mixture are usually adequate for a retropubic prostatectomy and analgesia is complete in about [illegible] minutes. If procaine is used analgesia is much slower in appearing.

Hazards

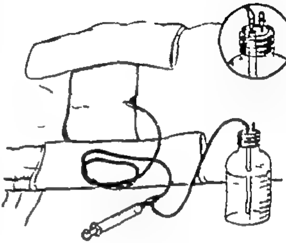
27 Chief among the hazards to this procedure are dural puncture, patchy analgesia due to septa and loculi, no analgesia due to needle being superficial to sacral hiatus, and the foetal head can be damaged if the needle be indiscriminately advanced. The illustration shows incorrectly placed needles (1) thecal tap (2) palpably superficial (3) entering the pelvis.



WRONG

CONTINUOUS CAUDAL BLOCK

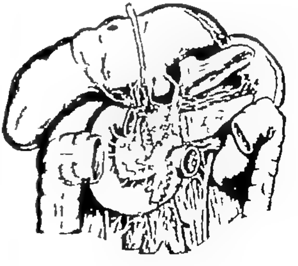
By means of continuous block with an indwelling catheter it is possible to anaesthetize up to the eleventh or twelfth dorsal nerves from which the uterine body derives its sensory supply The motor and sensory supply of the lower uterine segment, vagina and cervix is from the parasympathetic *via* the second and third and fourth sacral nerves. Provided analgesia does not rise above D.10 labour will continue and be painless.



Technique

28 The technique of Hingson and his colleagues can be recommended. A malleable unbreakable needle has been devised, but nylon catheters have been used with success. A primary dose of 8 ml is injected as before and provided no motor palsy develops in 5 minutes, a further 22 ml. are injected. After 20 minutes uterine contraction should be painless. Further doses of 20 ml. are required every 30–40 minutes (Metycaine, 1 ½ per cent, can be used) The catheter is attached to a syringe, stop cock and container by means of positive Luer-Lok connexions so that risk of sepsis is very small, but a disadvantage of the method is that the incidence of low forceps delivery is increased.

SPLANCHNIC BLOCK



29 The splanchnic plexus and coeliac ganglia lie between and around the aorta and inferior vena cava on the first lumbar vertebra above the upper border of the pancreas. Unless this area is blocked afferent visceral impulses pass to the sensorium and cause severe pain The splanchnic area may be blocked by the posterior approach (Kappis technique) or by the anterior after the abdomen is opened (Braun's method)

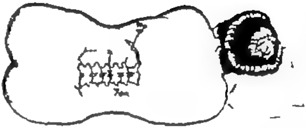
Indications

Splanchnic block can be used as a supplementary in upper abdominal operations where intercostal block or abdominal field block has been used. It is not needed with paravertebral block or epidural block. Its efficacy has been proved in pancreatitis in the relief of pain.

POSTERIOR BLOCK—KAPPIS TECHNIQUE

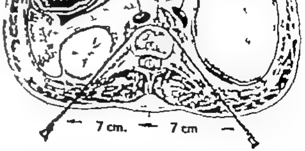
Technique

30 The spine of the first lumbar vertebra is palpated and a skin wheal raised four fingers breadth from it. This is actually at the border of the twelfth rib (7 cm.). Having raised a wheal, a 12 cm.-needle is inserted below the rib at 65–70 degrees with the skin. Proceeding towards the *midline it strikes the body of the* first lumbar vertebra. The needle is withdrawn about 8 cm. and its point directed more laterally so that it can be felt to slide over the lateral surface of the body of the vertebra. If the needle has been correctly placed, it will now be nearly at right angles with the skin. The needle should be advanced about 1.5 cm. when its point should have pierced the crus and be lying in the retroperitoneal space. The
31 needle should feel freely mobile in a vertical plane but movement should be restricted laterally. It is unnecessary to inject bilaterally for a single injection of 40 ml. will suffice. Injection should be easy and if there is any obstruction to the flow then the needle point is either *in the tendinous crus* or is lying against bone.



Hazards

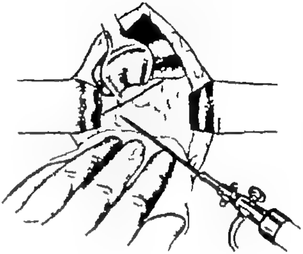
The great vessels may be punctured inadvertently. Blood pressure falls precipitately on occasion. If either the aorta or inferior vena cava be punctured, the needle should be withdrawn until blood ceases to flow and the injection should then be made.



(After Labat)

ANTERIOR BLOCK (BRAUN'S METHOD)

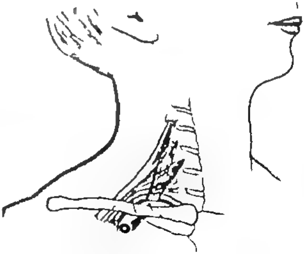
32 The index and middle fingers of the left hand displace the aorta to the left, and the needle point is thrust through the peritoneum of the posterior abdominal wall immediately above the pancreas in the midline to the right of the aorta, between it and the inferior vena cava. Between 40 and 60 ml. of solution may be injected.



BRACHIAL PLEXUS BLOCK

33 There are several methods of producing brachial plexus block, but the easiest and safest in the writer's opinion, is that performed by the supra-clavicular route, elaborated by Macintosh and Mushin. In semi-diagrammatic form the relations of the plexus are shown.

It will be seen that the subclavian vein is separated from the subclavian artery by the tendon of the scalenus anterior as it comes down to its insertion at the first rib. The cords of the brachial plexus come down posterior to and lateral to the artery as they cross the first rib.



(After Labat)

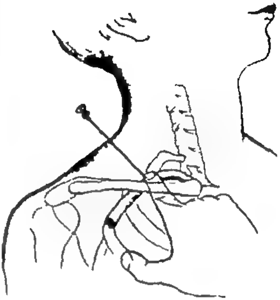
Indications

Brachial plexus block can be used for operations on the upper extremity, reduction of dislocation of shoulder and elbow joint and fractures of the upper extremities.

Technique

In a dorsal decubitus position the patient's head is turned to the opposite side the shoulder of the affected side being fully depressed. The subclavian artery is palpated, but should this prove difficult identification of the midpoint of the clavicle will assist. A pointer to this is the external jugular vein

34 The middle finger of the left hand is placed on the subclavian artery and a wheal is raised in the skin immediately behind the nail of the index finger The injection is made with a No 20 spinal needle or 3-inch needle. The needle should be aimed at the spine of the third dorsal vertebra, that is, downwards, backwards and inwards to strike the first rib which is crossed by the cords of the plexus. Should the needle strike a nerve a sharp pain will be felt. Interference with lower cord causes pain in inner forearm and hand with the upper cord, pain at outer part of arm and forearm. If no paraesthesiae are elicited the needle is advanced until the point touches the first rib and 20–30 ml. of analgesic are slowly injected. The first rib lies about 2 inches from the skin surface and sometimes less



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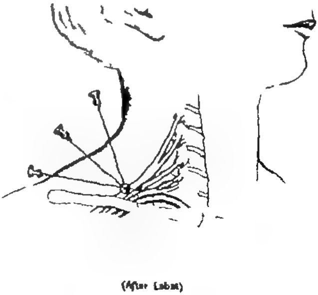
A modification of this technique is to place 10 ml of solution on the surface of the first rib

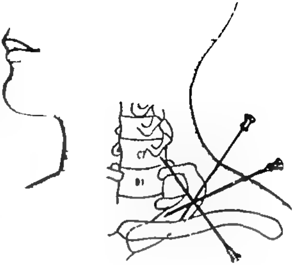
35 then the needle is directed towards Chassaignac's tubercle where 5 ml of 2 per cent procaine is injected and finally the needle is directed towards the lateral margin of the first rib behind the clavicle where another injection of 5 ml. of 2 per cent procaine is injected, making 20 ml. in all. Motor function is reduced but not abolished.



(After Labat)

The directions for blocking the brachial plexus sound much more formidable than the actual technique is in practice. The drugs used may be either procaine or lignocaine (Xylocaine) The former (procaine) may be used either as 1 per cent or 2 per cent solution. If the weaker solution be used there will be no motor paralysis but only sensory loss. For those who are inexperienced in the technique the addition of some hyaluronidase (300 Benger units to each 30 ml.) will greatly assist in successful analgesia.

36 A further modification if paraesthesiae be not felt is as follows The upper surface of the first rib is contacted with the needle so that the pulsations of the subclavian artery are transmitted to it 10 ml of solution are deposited between the first rib and the skin The needle is then reintroduced on to the first rib 1 cm. laterally from position 1 and another 10 ml are deposited a third injection is made similarly 1 cm. external to the previous one.



(After Labat)

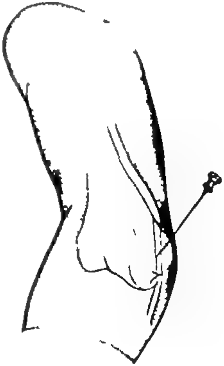
Hazards

Puncture of the subclavian artery and plexus is always possible, but usually no harm ensues. Two other factors to be borne in mind are paralysis of phrenic nerve, and puncture of pleura resulting in pneumothorax.

The extremities

Individual nerves can be blocked in the extremities at sites where they become reasonably superficial. However it must be emphasized that the blocking of fingers or toes by *injections around the digits themselves subcutaneously* is not without risk, particularly if adrenaline is added to the analgesic drug Bulk of injected fluid alone may so interfere with circulation as to precipitate necrosis of tissue. The nerves supplying the fingers can be blocked by injecting on either side of the respective metacarpal bones from the posterior aspect. Some 4–5 ml of procaine 2 per cent should be adequate

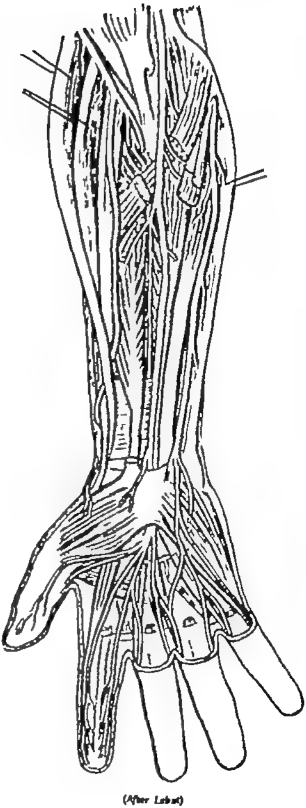
ULNAR NERVE BLOCK



37 This nerve supplies skin of the fourth and fifth fingers and the medial side of the middle finger on their palmar and dorsal surfaces. It is easily blocked by infiltration posteriorly between the medial epicondyle of the humerus and the olecranon 10 ml. of procaine 1–2 per cent are pooled around the nerve at this point.

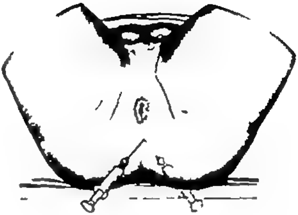
MEDIAN NERVE BLOCK

38 Median nerve block can be performed at the bend of the elbow. The nerve lies medial to the brachial artery which itself is medial to the biceps tendon. An injection of 10 ml. of procaine 1–2 per cent is made below the deep fascia, just medial to the pulsating brachial artery. The median nerve supplies the palmar aspects of the thumb, index, and middle fingers and also the nails of these digits. It can be blocked at the wrist by injection at the lateral side of the palmaris longus tendon. If the nerve be blocked here the flexion of the fingers is not interfered with. Blocking of the ulnar and median nerves at the elbow paralyses the digital flexors and the wrist flexors, and gives analgesia of the front of the lower forearm, the palm of the hand, and the fingers together with the inner dorsal surface of the little and ring fingers. The outer and dorsal surface of the hand is supplied by the radial nerve. The above are examples of blocks which can be performed on peripheral nerves of the limbs.

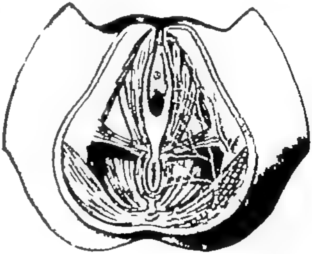


(After Labat)

INFERIOR HAEMORRHOIDAL AND PUDENDAL BLOCK



39 The patient lies on the right side with knees drawn well up Two *ounces of 2 per cent* procaine (or lignocaine 1 per cent) are required, to which is added 20 drops of 1 in 1 000 adrenaline. A skin wheal is raised 1 inch posterior to the anus. After inserting the first finger of the left hand into the anus, and using a 2 or 2½-inch needle an injection of 20 ml. of analgesic into perianal space and ischio-rectal fossa is given. The needle passes in anterior direction and at about 45 degrees to the skin surface. This gives relaxation of the anal sphincter and analgesia for operations on the anus.



Pudendal block is performed by passing the needle to the ischial tuberosity and depositing 5 ml. of analgesic posterior and medial to it. This blocks the posterior cutaneous nerve of the thigh. The needle is then directed hori-
40 zontally to the ischial spine and 5 ml. are deposited at this site to block the pudendal nerve where it enters Alcock s canal. Finally 5 ml. of the solution are injected along the superior portion of labia minora to block perineal branches of ilio-inguinal nerve. This is done on each side and is suitable for painless episiotomy and application of forceps.

[The illustrations for this Chapter on Local Anaesthesia—Technique were drawn by Mr F Price Illustrations 2–6 and 32 were redrawn by kind permission of Mr Harold Dodd illustration 1 by Down Bros and Mayer Phelps and illustration [illegible] by Messrs Eli Lilly]

POSTURE

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GENERAL PRINCIPLES

The posture of the patient is varied to facilitate the surgical approach, but even so a position which eases the surgeon's task may render things more difficult for the anaesthetist and even jeopardize the patient's well being by interfering with his cardio-vascular and respiratory systems. Even the nervous system may be seriously disturbed as a result of cerebral anoxia, and pressure on or stretching of individual nerves. The advent of the muscle relaxants has tended to increase the risk of palsy due to stretching of nerve bundles in certain conditions. Any exaggeration of posture should be avoided.

Surgeons vary in their methods of operating, and even differ in their views as to the position in which the patient should be placed for a particular operation. For example, the operation of haemorrhoidectomy is usually performed in the lithotomy position, but some surgeons prefer the patient in the left lateral posture, and others prefer the patient prone with the head and body tilted downwards and with the legs hanging down flexed at the hip joints. Thoracotomy is performed either in the lateral position or in the Parry-Brown posture which facilitates drainage of secretions from the lung. The degree of tilt used in the Trendelenburg position varies tremendously with the build of the patient, the difficulty of access, and the individual idiosyncrasy of the surgeon. A head down tilt of a few degrees is beneficial to the patient who is collapsed for it helps venous return to the heart and tends to keep the vital centres well supplied with blood. An extreme Trendelenburg position, however, can cause considerable respiratory embarrassment and chemosis around the eyes. Any exaggeration of posture may well cause respiratory difficulty not only in respect of diminished vital capacity, but also because the actual airway itself may be obstructed. Indeed, the integrity of the cardio-vascular system can be threatened very seriously by exaggerated posturing of the patient. Venous return to the heart can be seriously diminished by the undue elevation of a gall bladder or kidney rest, which actually may cause restriction of the lumen of the inferior vena cava. There can be serious and even fatal anoxia of the cerebral centres if the patient be wrongly postured after a hypotensive method has been used. The elevation of the head and upper part of the body under these circumstances must be done with the utmost caution, and should never be more than a few degrees from the horizontal.

The introduction of the relaxants into anaesthesia has increased the risk of nerve injury from stretching of the cords of the brachial plexus. Where there is a relaxed musculature a steep Trendelenburg posture with ordinary shoulder pieces may well overstretch the cords of the brachial plexus. Shoulder pieces should be so arranged that they bear on the acromio-clavicular joint and not on the soft tissues of the neck. Nerve damage, however, can arise solely as a result of posture and can occur when relaxants such as curare have not been used. Faulty positioning of the arms can cause stretching of the brachial plexus whether the arm be on a board or held by a nurse or dresser. In this latter instance fatigue on the part of the supporting dresser can allow the arm to sag posteriorly and thus stretch the plexus causing paralysis. Individual nerves can be damaged if the limb is allowed to hang over the side of the table (musculo-spiral palsy). Post-operative pain in the lumbar region is not infrequent when patients have been placed in the dorsal decubitus, and can be prevented if a folded bath towel or suitable sorbo rubber cushion be placed in the small of the back to prevent strain when the muscles relax under anaesthesia. The anaesthetist should be made aware of any limitation of joint movement there may be in the patient's limbs before any attempt is made at posturing him. In any case exaggeration of posture must be avoided and there are occasions when the desired position has to be modified owing to organic or skeletal disease.

DORSAL POSITION

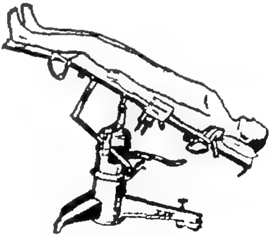
The patient lies on his back with head on pillow and arms to the side.

Points to observe

1 The heels should not be allowed to sag over table end but should be supported by bar of sponge rubber The lumbar region should have a pillow or folded towel to prevent sag and strain. Omission of this point can cause post-operative backache. The arms should be fixed either by curved supports or by a suitably folded towel forming a loop into which the forearm fits. Under no circumstances should the fingers be placed under the buttocks. Gangrene of the fingers has resulted from this practice. The knees may be supported by a pillow to help relax the abdomen (Dutton, 1932) but some consider that this increases the incidence of post-operative phlebothrombosis and pulmonary embolism.

TRENDELENBURG POSITION

2 The patient should be placed on the table so that the knees are at the bend where the foot piece joins the table. Some surgeons like the footpiece flexed as it saves some of the weight on the shoulder pieces. It was the practice of some to strap the legs to the footpiece avoiding the use of shoulder pieces altogether but this put pressure upon the calves and might well have been contributory to thrombosis and embolism. Hasler (1949) has described two serious consequences resulting from legs slipping and getting out of position when the footpiece is flexed. One patient sustained a pressure palsy of the external popliteal nerve and the other had to have a leg amputated for gangrene following injury to the popliteal artery

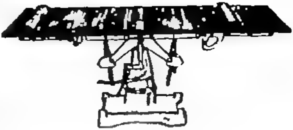


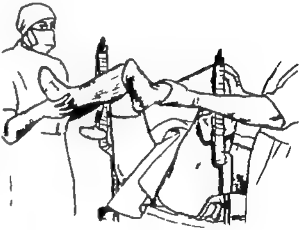
Points to observe

3 Shoulder pieces should be so arranged that pressure is taken on the acromio-clavicular joints, and under no circumstances should pressure be allowed on the soft tissues of the neck. Brachial palsy can arise from this. The writer devised shoulder pieces to avoid this, and yet hold the patient adequately However the best arrangement to date is the corrugated mattress of C. Langton Hewer The patient is placed on this with his back bare but special rubber pillows also corrugated on all sides are placed under the heels, lumbar region and neck. This is sufficient to hold a patient in the steepest Trendelenburg position. If iodine or any likely skin irritant is to be used care should be taken to see that none gets on to the mattress lest the fluid in the interstices cause skin reaction.

Apart from the above it must be stressed that it is wiser to keep the arms at the side and that intravenous drip tubing should be adequately long to allow this.

The anaesthetist must be alert for the possible regurgitation of fluid gastric contents if an intravenous muscle relaxant has been used. The use of the endotracheal cuffed tube is justified under these circumstances. The anaesthetist's task is further complicated by the fact that respiration is impaired by 17 per cent at a tilt of 22.5 degrees, and that some 20 per cent of the lung area is out of action in consequence (Altschule (1943) quoted by Hasler 1949)

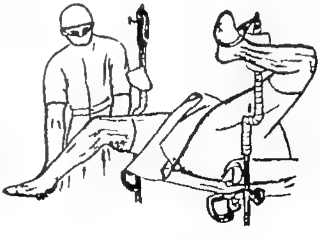




CORRECT LIFTING OF LEGS FOR LITHOTOMY POSITION

THE LITHOTOMY POSITION

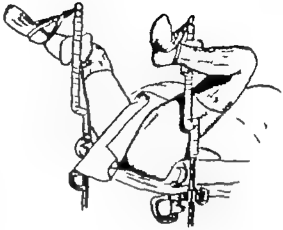
4 The patient lies supine with arms folded on chest. The thighs and knees are flexed and supported on canvas stirrups fixed to an upright. Case and Stiles (1946) state that the loss of vital capacity in this position is 18 per cent. This is due to the flexed thighs pressing on the abdomen and in the obese the resulting pressure on the diaphragm might well decrease the vital capacity even further The illustrations show the correct and incorrect way to lift the legs.



INCORRECT LIFTING OF LEGS FOR LITHOTOMY POSITION

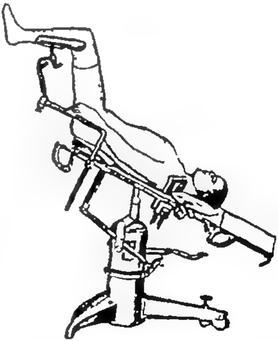
Points to observe

5 Both legs should be flexed simultaneously lest sacro-iliac strain result. The inside of the legs should be protected with a pad where they touch the upright. The patient must not be pulled too far down the table or severe backache may result. The diathermy pad electrode should be placed on the inner and posterior aspect of the thigh and covered with rubber and fixed with a bandage. This position is preferable to that under the sacrum or on the abdomen. The uprights should be at such a height that *the legs lie parallel with the body* and the uprights should be so arranged that there is no strain on the hips and adductor muscles. The patient need not be pulled down so far for cystoscopy or trans-urethral resection of the prostate as is the case when rectal or vaginal operations are to be performed.



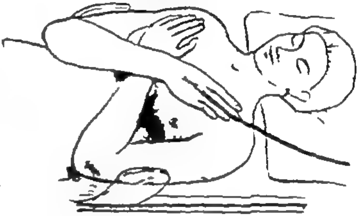
LITHOTOMY TRENDELENBURG POSITION

6 The thighs are abducted and flexed but are kept below a right angle so as not to interfere with abdominal access. The arms are fixed by the side and *the hands may be lightly fixed* with strapping to the thighs if need be. Shoulder pieces of the author's design can be used to hold the patient when tipped. It is important to see that the calves lie fairly in the metal supports and that there is no likelihood of pressure upon the vessels or nerves of the legs. The buttocks are pulled well down on to *the rubber sacral wedge, so that the lower end* of the sacrum can just, but only just, be palpated. The shoulder pieces are now fixed quite firmly so as to retain the patient in position when tilted. The legs are now finally adjusted and the arms fixed to the side. Vital capacity is impaired as in the Trendelenburg position.



The arms

7 Under no circumstances must the arm be allowed at more than 90 degrees from the side; it must not be allowed to sag posteriorly and the forearm should be fixed in pronation. Unquestionably the safest position is at the side. The illustration shows (1) the arm extended beyond the right angle with posterior sagging which should never be allowed; (2) supination of the hand which is inadvisable; (3) the hand pronated and the arm less
8 than a right angle which is correct. Failing this, it is possible (but not always) to maintain an intravenous drip if the forearm be flexed across the chest, while the upper arm is kept to the side by means of a moulded arm retainer placed just above the elbow.



The arms should never be placed abducted with the hands placed behind the head, for the brachial plexus can be stretched only too easily in this position.

If the inner side of the upper arm be allowed to overlap the edge of the table there is risk of damage to the musculo-spiral (radial) nerve.

SEMI-PRONE POSITION

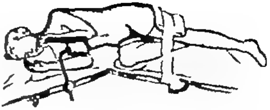
9 The patient's arms are placed as for the renal position but without the arm support. The lower thigh and leg are straight but the upper thigh and knee are flexed. It is important to keep the lower arm vessels from being occluded by pressure, and for this reason the lower arm is sometimes placed alongside the body posteriorly.

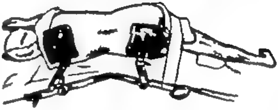
THE PRONE POSITION

10 The patient lies face downwards with the arms at the sides. A sandbag is placed across the upper chest so as to leave the lower part of the chest and the abdomen free to move on respiration. The vital capacity is diminished in this position and the use of an endotracheal tube is advised for general anaesthesia. Care must be taken to protect the face and nose from pressure when the body is in this position.

LATERAL OR RENAL POSITION

11 The patient is on the side with the lower arm pulled well forward and flexed at the elbow to ensure adequate circulation, while the upper arm is supported upon an arm rest so arranged that the arm is at right angles to the body and no more. The rest must be well padded and must support the wrist. The upper thigh and leg remain straight, but the lower thigh and knee are flexed, and a pad is placed under the knee. This helps to keep the trunk from sagging forward. Older tables were fitted with kidney rests which could be raised, thus stretching the upper loin, but it was possible to cause interference with the venous return to
12 the heart with consequent fall of systolic blood pressure. Modern tables break in the middle and, provided the patient has been properly placed, give adequate access to the kidney. The modified kidney position gives added support and stability to the patient and enables the table to be tilted laterally facilitating the access to the loin still more. Vital capacity is diminished in this position by 10 or 12 per cent.





THYROIDECTOMY

13 The Dunhill thyroid pillow is most satisfactory for this operation. The thin end is under the shoulders, the head is extended over the thick portion. Suitable adjustment of the pillow gives adequate exposure of the neck without tensioning of the neck muscles. The pillow is withdrawn slightly when re-suturing

[*The Illustrations for this Chapter on Posture were drawn by Mr F Price*]

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HAEMOSTASIS

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Hazards and complications of tourniquets

For first aid purposes it has long been taught that a tourniquet should not remain on for more than half an hour When a pneumatic tourniquet, or Esmarch bandage carefully and correctly applied is used for an elective operation on a limb with normal blood supply it is quite safe up to about 3 hours.

At the conclusion of an operation the surgeon must not forget to remove the tourniquet.

The tourniquet, if left on too tight, too long, will cause gangrene of the limb Traumatic arterial spasm of the segment of artery immediately under the tourniquet is also a serious hazard. This only occurs with the old Samway type of tourniquet applied roughly direct to the skin and too tight. If the pulses do not return immediately after release of the tourniquet this should be suspected, and the segment of artery under the tourniquet immediately explored. If the tourniquet is not tight enough venous congestion of the limb will be caused with increased bleeding

Haemophilics

If an operation on a known haemophilic becomes necessary (even a minor one, such as a tooth extraction) the patient must be prepared by a transfusion of at least one pint of fresh whole blood within 24 hours of the proposed operation. This temporarily restores the "anti-haemophilic globulin" and corrects their tendency to bleed for 3–4 days. Anti-haemophilic globulin can be obtained in a pure state for use in haemophilics, but it is better to use fresh whole blood, as this provides all the factors (including the "Christmas factor") which may be missing in a known haemophilic.

The use of drugs in haemostasis

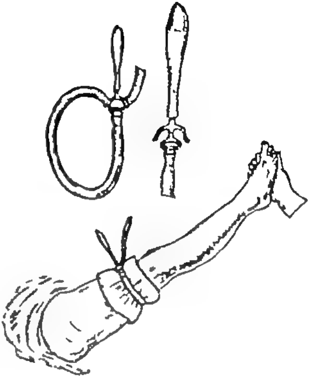
The value of the hypotensive drugs, in combination with posture, to produce a bloodless field is now recognized. The group of drugs, of which hexamethonium is the one most commonly used, cause peripheral vasodilatation by "blocking" the autonomic ganglia. They are long acting, that is to say the effect remains up to 1 hour after a single injection. The short acting drug Arfonad lasts only for 10–20 minutes after a single injection. This latter drug is extremely useful if a short period of hypotension during a long operation is required. Thus, in a Millin's prostatectomy Arfonad hypotension can be induced just while the prostatic sheath is opened and the prostate shelled out, to minimize loss of blood. The blood pressure is then raised to normal by the time the surgeon is ready to sew up the capsule

The hypotensive drugs are however potentially very dangerous and should never be used except by an experienced anaesthetist and surgeon who are used to working together For ordinary operations they are unnecessary and there are three great dangers. (1) During the prolonged period of hypotension perfect oxygenation of the blood must be maintained, otherwise certain vital organs, such as the heart and the brain, may suffer from fatal anoxia—particularly in elderly subjects. (2) The hypotension and vasodilatation completely mask the signs of shock or blood loss and make the problem of blood replacement during major surgery difficult to estimate (3) Reactionary haemorrhage is a real danger if haemostasis has not been very carefully effected, as the blood pressure comes up to normal levels soon after the end of the operation

PROCEDURE

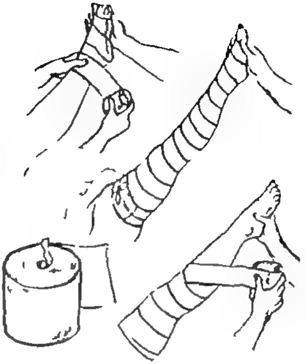
The Samway tourniquet

1 This consists simply of a length of heavy rubber tubing with a locking device at one end. It is the oldest type of tourniquet. There is no definite way of telling how tightly this is applied as it is applied by muscular force. If put on too tight, or without a towel, it may cause skin necrosis or spasm of the underlying artery. It should seldom be necessary to use this type of tourniquet in a theatre for an elective operation. Before applying a tourniquet it is advisable to elevate the limb for 2 minutes to drain it of blood. It is important that all tourniquets, particularly the Samway, should be applied over a towel or roll of gauze and never next to the skin.



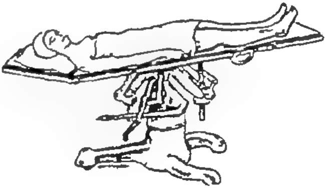
The pneumatic tourniquet

2 This is applied in the same way as the Samway. It is far less traumatic, as the pressure is more evenly distributed and its tightness is controlled. It is inflated to a little above arterial systolic pressure and maintained at this level throughout the operation or as long as required. It is the tourniquet of choice for an elective operation.



The Esmarch bandage

3 This consists of a firm rubber bandage. It is applied as shown with the limb elevated, and it is applied with turns which *only just* overlap each other from toes to thigh. The bandage is then unwrapped from leg (or forearm) to allow surgical access. The effect of this is to completely exsanguinate the part. This makes it exceedingly useful for the fine surgery of the hand—the surgery of tendon and nerve repair It is the method of choice for any operation on a limb which requires a long fine dissection in a bloodless field. It is usually best to apply a pneumatic tourniquet proximal to the Esmarch bandage rather than relying upon the tourniquet effect of the remaining turns of the bandage.



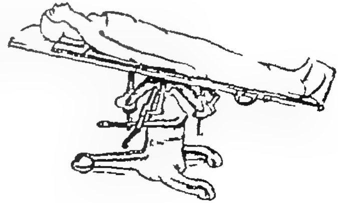
Postural haemostasis

Elevation of the part to be operated upon will diminish both the arterial pressure and the venous congestion.

In lower limb surgery

4 Thus, in operations on the legs, particularly on varicose veins, the table should be tilted head down—about 10 degrees.

In thyroid and surgery of the head and neck

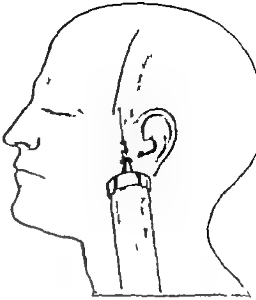


5 In thyroid surgery and surgery of the head and neck, the table is tilted foot down 10 degrees. Too great a tilt should be avoided, as when a large vein is opened this may result in air being sucked into it, and the risk of air embolism is present.

Drugs

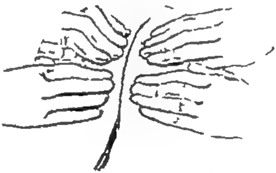
By pre-operative infiltration of the subcutaneous tissues along the line of the incision

6 This is best done with 1 per cent procaine or one of the longer acting procaine derivations such as amethocaine. It is best not to use adrenaline as well, as the injection of too much adrenaline has been known to cause skin necrosis. The haemostatic effect is simply due to the fluid tension which is built up in the subcutaneous tissues. This is particularly useful in operations on very vascular areas such as the face head, neck and scalp



Haemostasis by digital pressure

7 *Where an incision is made on the scalp or any other skin immediately overlying a bone, haemorrhage can be controlled by finger pressure on both sides of the wound.*



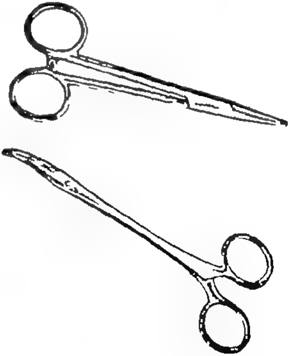
At operation

8 *If tissues are incised cleanly small vessels will retract and seal themselves off after a few seconds of swab pressure*

Small arteries and veins that are cut during incision of tissues are best picked up directly by haemostats (as shown) and either ligated or diathermized.

Larger named arteries and veins supplying an organ or part to be removed must be exposed and divided between ligatures as a definite manoeuvre.

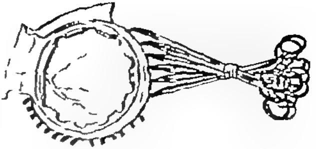
Before certain operations it is best to expose and either ligate or clamp the main blood vessel to the part (for example the external carotid before removal of the lower jaw)



Special methods to control haemorrhage

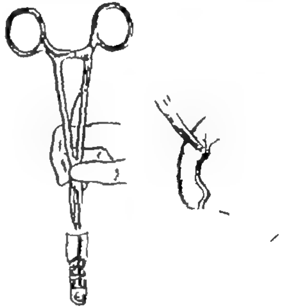
Scalp

9 In the scalp the vessels, which are very numerous and small, run close up against the galea aponeurotica. Haemostasis is obtained here by applying a row of artery forceps close together on the incised galea aponeurotica, as shown



Clips

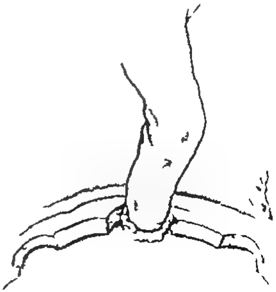
10 These may be used, as shown, to occlude small and delicate vessels before sectioning them. They are particularly useful in cerebral surgery for occluding the delicate branches of the cerebral arteries running over the brain. Also they are of great use in deep and narrow cavities where the application of a ligature would be difficult (as in the operation of cervical sympathectomy where they may be used to occlude a bleeding intercostal artery or vein) Clips can also be used as markers in surgical operations, as their position can be verified in a post-operative radiograph.



Bone wax and other haemostatic applications

11 Horsley's wax (phenol and beeswax) may be used to plug the marrow cavity of bones, which bleed profusely sometimes in the manner shown.

Oxycel gauze, fibrin foam, thrombin (various preparations) Russell's viper venom have all been tried out as local haemostatic applications to "oozing" surfaces. In the writer's experience, it is not advisable to rely on these preparations. They are not effective in stopping haemorrhage, and they act as foreign bodies when left in, and may actually precipitate a secondary haemorrhage later A very good haemostatic "stamp" application can be made by excising a small piece of muscle in the vicinity of the wound, and flattening it by squeezing it between two flat surfaces. This "natural" haemostatic stamp is preferable to and far more efficient than any artificial one



[*The illustrations for this Chapter on Haemostasis were drawn by Miss J Dewe*]

INFUSIONS AND TRANSFUSIONS

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INTRAVENOUS

Indication

Intravenous therapy is indicated for the replacement of deficiencies in the circulating blood, but it should never be undertaken lightly for it is not without risk to the patient. Before an intravenous infusion is given three questions must be answered. (1) In what elements is the circulating blood deficient, for example whole blood, serum, red cells or electrolytes? (2) Can replacement be accomplished more safely by other means, for example, by mouth? (3) If replacement cannot be made by mouth now can the deficit be allowed to continue safely for a while until replacement by mouth is possible?

Technique of Infusions

The continuous drip method is now always employed and standard giving sets are available ready sterilized either from the National Blood Transfusion service or from commercial firms. They consist of an attachment for the bottle of fluid to be used, so that air can enter into the bottle and the fluid leave by a flexible tube leading into a drip chamber From this the fluid passes through more tubing and an adaptor to the needle or canula inserted into the vein. The rate of flow is controlled by a screw gate clamp and is gauged by the rate at which drips pass through the drip chamber If non-standard sets are used great care must be taken to see that they are perfectly clean before sterilizing or troublesome pyrogens may enter the circulation. The troublesome part of the intravenous infusions is in inserting the needle or canula into the vein and keeping it there for the duration of the infusion, perhaps several days.

Wherever possible simple percutaneous venepuncture with an intravenous needle or special canula (Frankis Evans, Guest Birmingham Hospital) is desirable.

Advantages of percutaneous puncture

The advantages can be given as follows speed of operation less discomfort for the patient less chance of sepsis as there is no open wound *less risk of thrombophlebitis if the vein does thrombose it will recanalize and may be* used at a later date.

Contra-indications and disadvantages

The only contra-indication is inability to enter a vein and this becomes very infrequent after a little practice, particularly if the methods of increasing the calibre of the veins to be described are used.

When the vein cannot be entered through the skin, a cut down technique must be adopted, when it should always be possible to set up an infusion.

Disadvantages of a cut down technique are marked once a vein has been so used it is permanently blocked there is increased risk of sepsis frequent thrombophlebitis occurs sometimes with embolization it is time consuming and uncomfortable for the patient.

PERCUTANEOUS METHOD

Choice of suitable veins

The arm is more suitable for use than the leg, for be- e arm having the patient is less im- mobilized and can move about in bed by his own effo is less risk o lebitis as circulation is better It is also more convenient to operator nurses a use the up

1

A suitable vein is one which is of good calibre is straight over a distance of 2 inches and is well clear of a joint so that normal movement of the arm will not interfere with the needle Its position should be such that when the infusion is proceeding the limb can rest comfortably

The most suitable veins are those in the middle reaches of the forearm, especially the radial vein, which is very constant over the lower one-third of the radius. In some patients the veins are of small size and not easily visible whilst in others reasonable veins are rendered difficult to enter by intense venospasm associated with cold, shock, blood loss or simple fright.

Efforts should be made to improve the calibre of the veins (1) By using a sphygmomanometer cuff as a tourniquet applied at diastolic pressure 10 minutes before attempting venepuncture. (2) With a tourniquet in position, application of warmth by a lamp or a well-protected hot water bottle. Great care must be taken not to burn the skin, particularly in shocked patients. Other methods are asking the patient to open and close his fist repeatedly and stroking the veins towards the tourniquet. This may be done quite briskly providing no force is used, for the stimulation seems to cause vasodilatation.

The superficial veins are always more prominent under general anaesthesia and if the infusion can be left until that time, it is easier to set up The antecubital veins, though very prominent in most people and easy to enter should not normally be used because of their position in front of a joint, but if the patient is collapsed with veins difficult to find and transfusion is a matter of urgency there should be no hesitation in using them temporarily If necessary a more suitably placed vein may be used later when the circulation has improved sufficiently for this to show up.

Apparatus

The following apparatus is assembled. (1) Bottle of intravenous fluid with hanging bracket. (2) Sterile giving set. (3) Eccentric nozzled 5 cc. syringe. (4) Intravenous canula of Guest, Birmingham Hospital, Frankis Evans or other pattern. (5) Drip stand for suspending the bottle. (6) Sphygmomanometer (aneroid type is most convenient) (7) Adjustable gate clamp. (8) Bottle for blood sample if required. (9) Mackintosh sheet. (10) Six pieces of ½ inch adhesive tape 6 inch length.

CUT DOWN TECHNIQUE

Apparatus

The equipment required for setting up "cut down" infusion is as listed for percutaneous method, without the intravenous needle but plus the following (1) Intravenous cannulae—Hamilton Bailey pattern in three sizes are recommended. (2) Small skin knife. (3) Two blunt hook retractors. (4) Aneurysm needle. (5) Pair small stitch scissors. (6) Three pairs fine artery forceps. (7) Pair small dissecting forceps. (8) Small reel of 60 thread. (9) Two small curved cutting needles. The above articles are conveniently left together as "sets" in a metal box autoclaved ready for use but of course they can be boiled up as required.

Choice of vein

Any superficial vein may be used for infusion by the cut down technique, though a convenient situation should be chosen as described for percutaneous methods. The method is normally used when veins are difficult to locate from the surface and it is important to know constant situations in which to cut down with certainty of finding a suitable vein. These are (1) the internal saphenous vein which constantly passes upwards in front of the medial malleolus of the ankle (2) the radial vein which always passes proximally for about 5–6 cm. from the radial styloid on the lateral surface of the lower end of the radius.

MAINTAINING INFUSIONS

Once an infusion is set up it is in everyone's interest to keep it running smoothly There must be no constrictions of the veins by badly placed needles, bad positioning of the arm or unnecessary splinting The bottles must be

changed regularly and not allowed to run dry. Irritant infusions should not be used wherever possible and any drugs which are injected by this route should be well diluted.

Correcting a slow running infusion

Sometimes the infusion runs very slowly because of venospasm, either general, due to collapse, or local, due to cold or irritation of the vein. Improved running may be obtained by gently warming the arm, injecting 2 ml. of 1 per cent procaine hydrochloride through the tubing of the giving set, or increasing the pressure of the infusion either by raising the height of the bottle or increasing the air pressure in the bottle with a Higginson's syringe. If this last-mentioned method is used, great care must be exercised, the infusion watched continuously and the pressure stopped as soon as the fluid level reaches anywhere near the out-flow tube, or a massive air embolus may follow.

Displacement of the needle

If the needle becomes displaced from the vein, the infusion will run subcutaneously and must be stopped at once. After a variable period of running, the vein becomes inflamed and will rapidly clot (thrombophlebitis). The earliest sign of this occurring is pain or tenderness in the vein proximal to the needle. This should be looked for carefully twice a day and if found, the infusion discontinued or transferred to another vein. If allowed to proceed to thrombophlebitis the limb will be very painful for 10 days and the clotting may be so extensive as to prevent *the use of that limb for further infusions for 8 weeks.*

If inflammation repeatedly appears 24 hours after setting up an infusion, or if it is anticipated because of the irritant solution used, or it is known that an infusion will be required for a long time, heparin may be added to the infusate. If this is done in such quantity that not more than 2 000 units enter the circulation every 6 hours, the local effect will usually be adequate, but there is no risk of increased haemorrhage even in the post-operative phase.

THE PROCEDURE

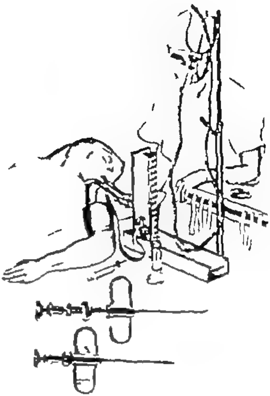
PERCUTANEOUS METHOD

Preparation for infusion

1 The patient is sat comfortably in bed, the procedure explained and if he is restless a sedative administered. The arms are examined for suitable veins and if possible the left arm used in right-handed people and *vice versa.* First the selected arm should be shaved and *the sphygmomanometer cuff* is applied well up the arm with the tubes towards the shoulder and inflated to diastolic pressure. The forearm is placed comfortably on a pillow which has been covered by a warmed mackintosh; the limb is left to congest whilst the apparatus is assembled. It is at this stage that heat may be *applied if necessary* and *under no circumstances* should the arm be cooled by draughts or cleaned with ether.

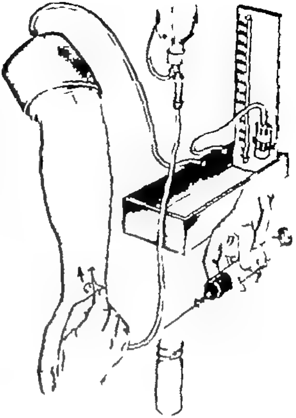
The giving set

2 The giving set is assembled connected to the bottle of fluid which is then hung on to the drip stand placed by the patient's shoulder The tubing is allowed to fill with fluid, the level in the drip chamber adjusted, and a clamp applied. The stilette is removed from the combined canula and after testing for easy separation of needle and canula it is affixed to the syringe with the needle bevel upwards. An assistant is stationed by the patient's shoulder and instructed how to deflate the sphygmomanometer and hand over the open end of the giving set.



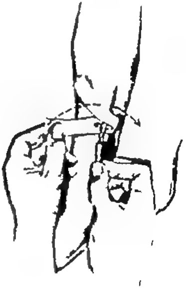
Point for venepuncture

3 If the vein chosen is not distended it is briskly stroked with the forefinger When the calibre is adequate the operator grasps the patient's wrist with his left hand so that the left thumb pulls distally on the vein and fixes it. A suitable point for venepuncture is chosen this should be well away from the wrist and elbow joints and preferably near where a tributary enters the chosen vein and will help prevent lateral movement during puncture. With the needle canula mounted on a syringe in the right hand, it is pushed briskly through the skin into the vein and advanced about $\frac{1}{4}$ inch. The syringe piston is withdrawn to see if the needle is well into the vein and if blood flows back freely the assistant is instructed to deflate the sphygmomanometer and whatever blood is required is withdrawn into the syringe. Local anaesthesia is not required and may be a disadvantage as it "hides" the vein.



Attaching the feed

4 The needle, still attached to the syringe is withdrawn from the canula and handed to the assistant, who later can empty the blood *into the specimen bottle. At the moment,* however he hands the lower end of the giving set to the operator who attaches it to the shank of the canula. The drip now is allowed to flow at its maximum rate so that the fluid running from the end of the canula in a solid stream will distend the vein in front of the canula which can now be gently advanced up *the vein with a snake like movement till the* full length of its shaft is buried. If a special canula and needle is not available the same technique can be used with an intravenous needle of suitable size.



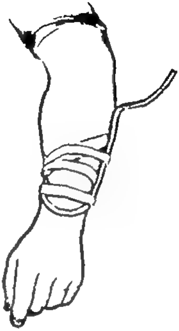
Fixing the canula

5 Whilst the operator holds the canula steady in the correct position the assistant places one 6-inch length of adhesive tape, sticky side up under the flanges of the canula and each end *is folded over as shown. This stops further* withdrawal of the canula.

Fixing the canula and tubing

6 A second 6-inch piece of adhesive tape is now placed over the flanges and round the arm. The tubing is now adjusted so that it lies in a comfortable U on the dorsum of the arm, clear of the wrist and the elbow joint, and fixed by two further 6-inch lengths of adhesive tape. The more proximal of these passes over the rubber tube, then over the canula, where it is buried in the vein just short of its tip, thus minimizing movements of this and consequent tendency to puncture the wall of the vein. If the needle has been correctly inserted so that all the attached tubing is clear of the joints, all that is now necessary is to place a loose collar of gamgee around the forearm and the patient instructed not to make too much movement with that arm, normally leaving it comfortably at rest on a suitably placed pillow.

However, if movement of the wrist is liable to interfere with the position of the needle, the arm should be lightly fixed with 1-inch adhesive tape on to a well-padded forearm splint. In the unusual circumstance when the needle has had to be inserted near the elbow joint, of course, a larger splint must be used, but even here wherever possible the forearm should be at least partly pronated as it is much more comfortable.



CUT DOWN METHOD

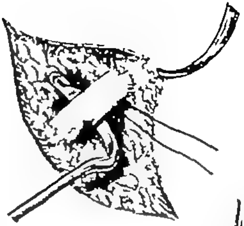
Choice and exposure of vein

7 After choosing the vein to be used the appropriate area is shaved, a sphygmomanometer placed well above, inflated to diastolic pressure, the giving set is prepared as previously described and a 1.5–2 cm. transverse incision is made through the skin 4 cm. above either the medial malleolus or the radial styloid. Once through the skin the knife is discarded and the incision deepened by inserting the points of a pair of artery forceps into the fat and opening them in the direction of the vein. Gradually the fat is opened away from the incision and the vein is exposed. In the case of the radial vein there is often a sheet of fascia binding it to the bone and this needs to be dissected.

Tying off the vein

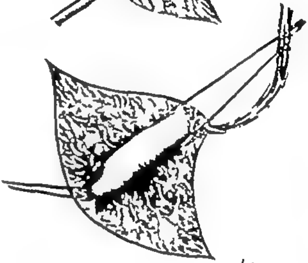
Distal end

8 The vein is freed from the surrounding fascia. The aneurysm needle is loaded with an 8-inch piece of 60 thread (some surgeons prefer 00 catgut) and a ligature passed under the distal part of the vein tied, the ends left long and held in a pair of artery forceps as a retractor



Proximal end

9 A second ligature is similarly passed under the proximal part of the vein, but left loose with a single hitch, the long ends again being held in a pair of artery forceps.



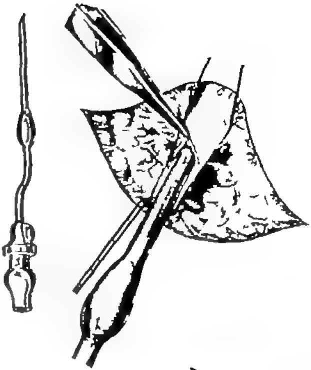
Incision of the vein

10 With the two ligatures holding the vein taut, a transverse cut is made in the anterior wall with a pair of pointed scissors. The sphygmomanometer cuff is then deflated.

Inserting the canula

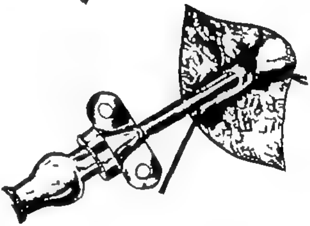
11 A canula of correct calibre for the vein is chosen. Lifting the cut edge of the vein the canula is inserted into the proximal portion, until the bulge on its shaft has passed well into the lumen

Care must be taken to see that the canula is truly in the lumen and not stripping up the intima. It is for this reason that the veins were allowed to congest, when, if the canula is correctly situated, blood will flow back through it.



Connecting the adaptor

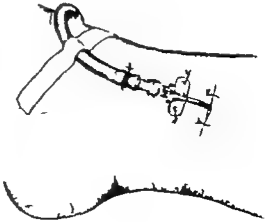
12 The adaptor of the giving set is now connected to the canula and the fluid allowed to run. When this is seen to be satisfactory the proximal ligature is tied tightly on the foot side of the canula bulge so that a watertight junction is made and the canula prevented from slipping out of the vein The two ligatures are cut short.



Securing the giving set

13 The wound is now approximated with two thread sutures and the canula and giving set secured by stitching to the skin, one stitch passing over the Luer connexion at the end of the giving set. A small sterile dressing is applied to the skin with 6-inch lengths of adhesive tape

When the time comes to take down the transfusion, the stitches holding the canula are cut and it can then often be withdrawn by a sharp pull, but if this fails the wound must be re-opened, the proximal ligature cut and the skin re-sutured. A firm dressing will stop any tendency to bleed.



INTRA-ARTERIAL TRANSFUSION

Indications

Severe shock, following trauma or blood loss that fails to respond to normal methods of resuscitation If, despite control of the blood loss, adoption of the Trendelenburg position maintenance of efficient oxygenation and the rapid intravenous transfusion of 2 pints of whole blood the cardiac output does not improve as adjudged by the blood pressure remaining below 60 mm. Hg, the heart rate not slowing intra-arterial transfusion should be considered. Particularly is this indicated if there is pooling of the blood on the venous side that is, despite adequate filling, the heart cannot improve its output. This is indicated in the condition sometimes known as "irreversible shock" though some workers believe it to be a desirable method of preventing such a state arising in the presence of massive bleeding The principle of the method is that by putting blood into the arterial side of the circulation *the arterial blood pressure and especially the blood flow are rapidly increased leading* to improved tissue oxygenation particularly of the heart with consequent ability to further improve its output.

Situations in which intra arterial transfusion may be required

Intra-arterial transfusion may be employed in cases of massive acute haemorrhage due to bleeding peptic ulcers or during certain thoracic or cardio-vascular operations. Other conditions are, following very severe trauma, where severe oligaemia has continued unchecked for several hours, and for shock in the presence of a cardiac lesion (coronary thrombosis, or haemorrhage in a patient with myocardial disease) When intra-arterial transfusion is required it is usually required in a hurry and so the apparatus should be kept assembled and sterilized in a drum

Methods

Intra-aortic infusion can be obtained by percutaneous puncture as described by Haxton, and by direct insertion of a needle into the aorta providing this vessel can be easily exposed through the field of operation. Other methods of transfusion are by insertion of a needle into any large vessel that can be conveniently exposed either through the field of operation or in a limb—the femoral (the needle must be inserted towards the heart)—and tying a canula or needle into the radial or dorsalis pedis artery

Fluid

Blood only should be used. This should be as fresh as possible for the longer it has been stored the more potassium leaves the cells for the plasma and theoretically a lethal concentration may reach the coronaries. Heparin, 1,000 units, should be added to each pint to reduce the risk of clotting and peripheral embolization The use of fluid other than blood is dangerous for if this perfuses the limb there is greatly increased risk of ischaemia.

Rate and volume of intra arterial transfusion

This is to some extent self-governing and is a great advantage of the method. The transfusion pressure is maintained at the patient's normal systolic pressure until the desired clinical improvement is obtained. This usually *occurs after as little as 800 ml. of blood Further blood* is transfused as indicated, to maintain the condition of the patient when stability is achieved the transfusion may be changed if desired to the intravenous route.

Complications

Ischaemia of the limb distal to the canula, peripheral embolism and air embolism may arise

Apparatus

That described by Professor Mushin (*Lancet* 1954 p 20) and made by Medical and Industrial Equipment Ltd., is convenient and satisfactory *I am indebted for the following description* of the apparatus which consists of the

llowing Metal screw cap to fit standard blood bottle and metal tubes with E.M.S type filler 'The Oxford fety Dripper' for the prevention of air embolism heavy gauge connecting rubber tubing tubing Y piece bing clips wide bore transfusion needle standard sphygmomanometer bulb of sphygmomanometer

PERCUTANEOUS INTRA-AORTIC TRANSFUSION

dvantages and disadvantages

The aorta is constant in position and always has a wide lumen however much vaso-spasm be present, and it an be entered with speed and certainty The transfusion will not be hampered by spasm of the vessel Negligible sk of thrombosis and distal ischaemia. It is often awkward to move a severely shocked patient into the lateral or prone position This is more marked, of course, during operation but then it may be possible to approach the orta direct from the site of operating

quipment

A suitable adaptor is added to that already described Also a 14 cm. 2 mm. bore needle is required. (Haxton ecommends a special stepped needle with a stem 14·6 cm. long and 2·8 mm. diameter terminating in a section cm. long and 1 ·5 mm. in diameter This gives better rate of flow with a smaller puncture hole in the aorta.)

RADIAL ARTERY CANALIZATION

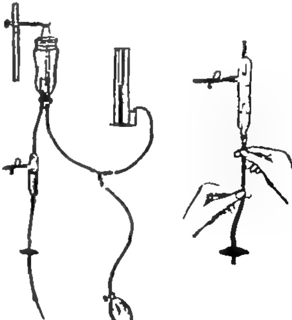
No equipment is necessary other than that previously described. The attached transfusion needle or canula can e used if preferred. The left is the arm of choice If time and circumstances permit, a left cervical sympathetic lock with 2 per cent Lignocaine is performed. When the transfusion is completed, the proximal ligature is cut, he canula withdrawn, a further ligature applied and the wound closed. The hand is carefully examined for any igns of ischaemia. If present the arm is kept cool and a stellate ganglion block with 2 per cent lignocaine per-formed. It would appear that if restoration of the blood pressure is prompt and permanent the risk of ischaemia o the hand is small.

As with all methods of resuscitation, if the cause of collapse is still operative steps must be taken to stop this as oon as an improvement has been obtained in the general condition.

THE PROCEDURE

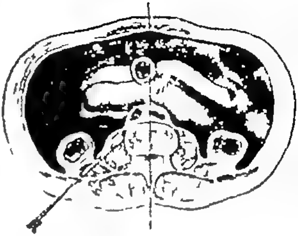
Apparatus

14 The apparatus is shown assembled, with the various connexions wired to prevent separation under pressure. The apparatus is sterilized as a whole. The float is shown raised in the smaller illustration when the apparatus is being set up as it may stick to its seating after sterilization



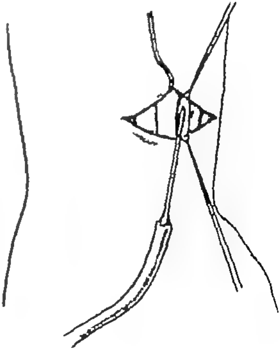
Percutaneous intra aortic

15 The patient is placed on his right side. The *skin of the back cleaned with 2 per cent iodine* in spirit. With 2 per cent procaine a skin weal is raised 10 cm. to the left of the third lumbar vertebra and a track down to the body of the vertebra infiltrated. The skin is nicked with a fine tenotome and the transfusion needle introduced towards the body of the third lumbar vertebra—an angle of about 40 degrees. When the point touches the side of the body of the vertebra it is withdrawn and re-advanced so as to slide off the front of the vertebra and then advanced until the aorta is penetrated and the point lies 1 cm. within its lumen. As soon as the blood pulses out, the transfusion set is connected and the blood put in under about 250 mm. Hg pressure. The needle is quite stable in this position but for added security a pair of straight artery forceps lying flush with the skin can be clipped on to the needle and the forceps firmly affixed to the skin of the back with adhesive tape.



Radial artery canalization

16 A transverse incision is made over the radial artery 8 cm. above the radial styloid, the artery identified and cleared over a length of 8 cm., and left covered with a swab soaked in 2 per cent procaine whilst the apparatus is assembled. This is to reduce spasm. A ligature is passed round the artery and tied distally. *A second ligature is passed* round the artery proximally but left loose with a half-hitch. A transverse cut is made in the anterior wall of the artery and the needle or canula inserted well up the lumen. The proximal ligature is then tied over the canula to prevent leakage (a technique essentially similar to cut down intravenous infusion). Procaine, 2 ml., is injected *via* the rubber tube to try and further reduce spasm of the artery. On some occasions after exposure of the artery it may be possible to puncture it directly with a needle with the theoretical advantage of finishing with a patent artery. However the risks of bleeding around the needle and subsequent spasm and thrombosis are so great that most surgeons prefer ligation.



DIATHERMY

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GENERAL PRINCIPLES

The coagulation of tissues by heat applied either in the form of hot oil or a hot metal has been used by surgeons since the earliest times. The development of diathermy has made possible the accurate local and well controlled use of heat to coagulate or cut tissues cleanly

The large neutral electrode

The large neutral electrode is usually a thin flat sheet of lead of about 6×9 inches, and is connected to the earthed terminal of the generator It is malleable, so that it can be closely moulded to the part to which it is applied. It is best applied to the thigh or arm, moulded closely to the part and bound on with a crepe bandage. Before being applied to the part, both the skin and the contact side of the electrode are liberally smeared with a mixture of glycerine and soft soap (animal soap 2 ounces lemon oil, 80 minims glycerine, 8 ounces distilled water up to 1 pound by weight) This mixture ensures perfect contact of the plate to the skin over the whole of its area, even on hairy surfaces.

This question of getting perfect wide contact with a minimum of electrical resistance is of vital importance if accidental diathermy burns are to be avoided (see page 60)

Complications

Accidental burns

Should contact arise between the patient and the table burns may be caused, a point which has considerable medico-legal significance

Other ways in which accidental burns may occur are as follows. If the active electrode is allowed to touch any other instrument (such as a towel clip) in contact with the skin, while the current is on In a long session of diathermy of a papilloma of bladder the water in the bladder may become dangerously hot if not changed frequently During prolonged diathermy with the active electrode at the tip of a slender organ, such as a finger or a child's penis, a dangerous amount of heat may be generated, leading to coagulation necrosis.

Diathermy should never be used in the vicinity of the eyes.

Diathermy explosions

Diathermy should not be used when an explosive anaesthetic agent is being used. The two main anaesthetic agents which are dangerous in this respect are open ether and cyclopropane. This is particularly relevant in any operation done in small ill-ventilated rooms, and in operations on the lungs themselves, or in the mouth

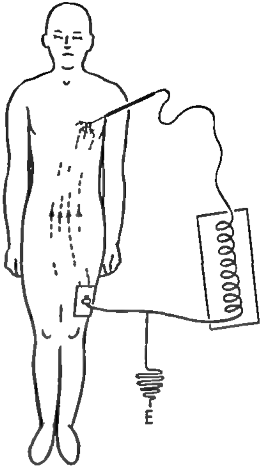
Post operative pain

After excision of superficial lesions by diathermy there is a good deal of post-operative pain for 24 hours or more as might be expected with a burn.

TECHNIQUE

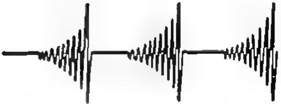
Principle

1 If a high-frequency oscillating current is passed through the body from a large neutral electrode to a very small "active" electrode there is an intense concentration of current under the small active electrode. This results in a destructive heat effect, leading to the immediate coagulation or disruption of the tissues immediately under the active electrode. Note that the heat generated is in the tissues themselves immediately under the active electrode the electrode itself remaining cool.

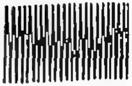


Current variation

2 To get a predominantly coagulation effect or predominantly cutting effect the type of current is varied. There are two wave forms for the high-frequency oscillating currents for diathermy cutting and diathermy coagulation respectively. The sustained oscillating current produces an explosive disrupting effect on the tissues under the active electrode. The damped current produces more coagulation and less disruption.



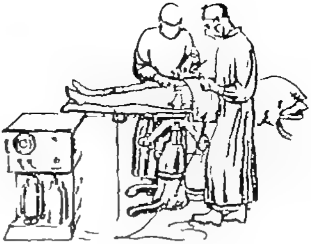
Current for coagulation



Current for cutting

Details of use

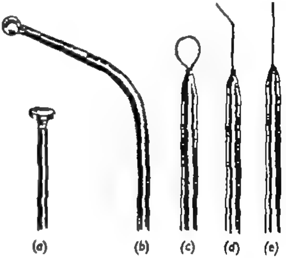
3 The general set-up for the use of diathermy in routine surgical operations is shown. The make and break of the current is controlled by a foot switch. The type of current supplied (diathermy cutting or coagulation) can be selected by a switch on the machine.



The active electrode

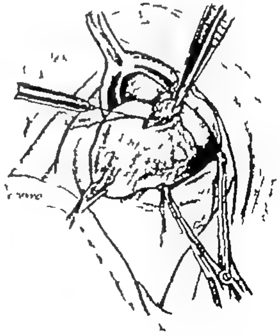
4 The active electrode can be of several types.

(*a*) Button end.
(*b*) Ball end.
(*c*) Loop.
(*d*) Angled needle.
(*e*) Straight needle.



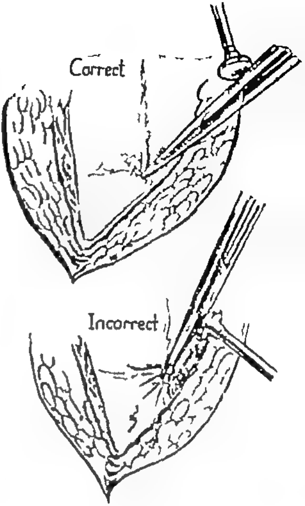
Tumour excision and tissue coagulation

5 The active electrode can be used directly as in the diathermy excision of tumours with the cutting current, or to coagulate tissue as in cystoscopic coagulation of papillomas of the bladder. The illustration shows a papilloma of the tongue being removed with a diathermy needle and cutting current.



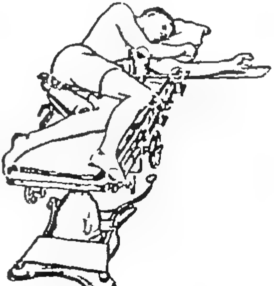
Treatment of bleeding points

6 It can also be used indirectly to coagulate bleeding points which have been picked up by artery forceps. To get adequate haemostasis by this technique two important points must be attended to These are (1) The bleeding vessel must be picked up accurately If it is merely picked up on a large bunch of tissue, the coagulating current may not coagulate the vessel itself. Right and wrong methods are shown The end of the artery forceps and tissues in the immediate vicinity must be dried properly before applying the current. Adequate coagulation will not occur in a pool of blood. It is important to realize that accidental burns may result from thus dealing with too large a number of bleeding points in too rapid succession.



Possible danger points for accidental contact

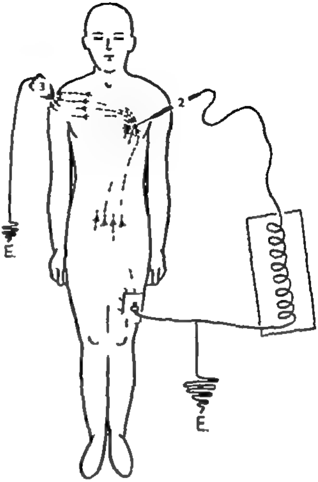
7 There are various places where accidental contact with metal parts of the table may take place Such accidental contact is more common when the patient is in special positions, such as the lateral thoracotomy position or the lithotomy position. Such diathermy burns are usually deep and involve full thickness skin loss. The black rings show the points of possible accidental contact.



Diathermy burns by accidental contact

8 Diathermy burns may occur when a piece of earthed metal, usually part of the operating table is in contact with the bare skin of the patient. Current may then take the alternative path from the active electrode to the earthed metal accidentally in contact with the skin if the resistance of this alternative path is lower than that between the active electrode and the neutral electrode.

Thus, the perfect contact over a large area at the neutral earthed electrode is essential for safety. In this connexion the practice of placing the neutral electrode under the patient's buttock with a saline pad for contact must be condemned. During a long operation the saline pad may dry out. Also the skin and fat of the buttock become relatively ischaemic as it is bearing the patient's weight and blood is expressed from it. Ischaemic skin and fat have a higher resistance than normal and less readily lose heat. These two factors may combine to make the resistance at the neutral electrode dangerously high and predispose to an accidental diathermy burn.



1 Neutral electrode
2. Active electrode
3 Accidental contact

[The illustrations for this Chapter on Diathermy were drawn by Miss J. Dewe.]

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NEEDLE BIOPSY

P F Lucas, M.D (Cantab.) M.R.C.P (Lond)

Physician to the Bournemouth and East Dorset Group of Hospitals lately Medical Tutor to St. Bartholomew's Hospital

PRE-OPERATIVE

Indications

The only limits to the use of needle biopsy are accessibility of tissues and size of tumour Fluoroscopic or x-ray control has been used for precise localization of bone and lung lesions. Useful information is acquired in 60–80 per cent of all cases. The method finds its most valuable application in suspected malignant disease in which a diagnosis, but not always of the precise type of malignancy can be made in nearly 90 per cent of cases with a high degree of accuracy Diagnosis of tuberculosis, Hodgkin's disease and other reticuloses is often possible Bone marrow and liver biopsy often give the diagnosis in obscure systemic disease The technique chosen depends on the proposed method of examination as well as on the site of the lesion.

Special contra-indications

The possible presence of a vascular anomaly or hydatid cyst may be a contra-indication a haemorrhagic state is an absolute contra-indication to liver spleen or lung puncture which should never be carried out unless bleeding, clotting and prothrombin times are normal they should not be attempted if there is suppuration in the neighbourhood, nor if the dullness of liver or spleen cannot be percussed. Failure may occur if there is ascites or pleural effusion.

Special apparatus

For cytological and bacteriological examination 18 gauge needles are used, 6–16 cms. long and fitted with stylets. Short needles make for better control. A well-fitting 20 ml. syringe gives adequate suction. For spleen and marrow biopsies the needle should have a movable guard. The needle used for marrow puncture is shorter and of wider bore. Thick needles should not be used for other purposes.

For histology a larger core of tissue must be obtained. *The best means is a trephine type of needle fitted with a trocar and driven by an electric dental drill.*

For liver biopsy a special needle and syringe is generally used, fitted with a stylet and guard, which permits very rapid instrumentation. This has also been used for biopsy of lung, spleen and other tissues.

Numerous special needles and modified punches of small calibre have been used but have no advantage. All needles must be kept dry and sharp

Pre-operative preparation

For the majority of cases none is necessary If the patient is unduly anxious, a sedative such as Omnopon ⅓ gr or phenobarbitone 1½–3 gr may be given 1–2 hours previously An analgesic (Omnopon ⅓ gr) should be given ½–1 hour before liver or spleen biopsy For these latter and for lung puncture the patient must be in hospital and must be co-operative to the extent of being able to hold his breath at the proper time

Anaesthesia and position of patient

Local analgesia with 2 per cent procaine is used in all cases. It is of particular importance to infiltrate down to the capsule of liver peritoneum over spleen, pleura over lung and periosteum over bone.

Position must be chosen to give the best access. Patients for liver and spleen biopsy should lie supine on the edge of the bed. *In lymphadenopathy the softest most recently enlarged node is best.*

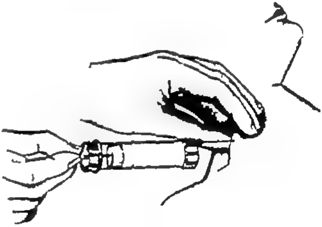
THE OPERATION

Preliminary puncture

1 A nick is made in the skin to allow easier penetration of the needle. The swelling is firmly fixed between thumb and forefinger of the left hand, avoiding massage of it a finger in the mouth assists fixation of a submandibular swelling The needle with stylet in place to prevent entry of skin and tissue fluid, is pushed in until the capsule of the tumour is just penetrated. The character of the capsule may give some indication of the nature of the lesion. When penetrated the tumour will move on lateral movement of the needle. The stylet is withdrawn and the syringe connected.

Obtaining the specimen

2 The plunger of the syringe is drawn out and held out with the right hand while the needle is pushed into the tumour Suction must be maintained until the needle has been withdrawn to the capsule, and then slowly released. Too much suction applied to soft tumours results in blood contamination. If pressure is not slowly released, tissue may spatter into the syringe or tissue fluid may be drawn in Aspiration of tissue into the syringe is undesirable the few drops in the needle being generally adequate. In hard tumours, the needle may be re-introduced in a slightly different direction without again penetrating the capsule. If a drill is being used, the butt of the needle is attached to the chuck of the drill and the needle pushed into the tumour with the drill running so that a cylinder of tissue is bored out. The syringe is then attached and the needle withdrawn while applying suction.



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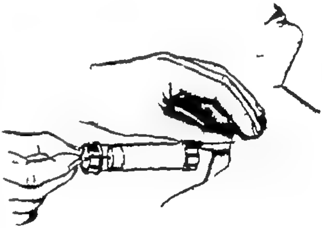

POST-OPERATIVE

The contents of the needle is pushed on to grease-free glass slides with the stylet the last drop being blown out with the syringe. The tissue is smeared by firm pressure of another slide so that the cells do not overlie one another Smears are stained by the May–Grunwald–Giemsa technique or other bacteriological stain. Particles or cores of tissue for histology are pushed into 10 per cent formol saline Masson s alcohol picroformol or Schaudinn s fluid.

Most pathological cells are abnormally large and can be recognized under the lower powers of the microscope Malignant cells, if present, are usually easily found and in lymph nodes or tumours a diagnosis of neoplasm should not be made unless 60 per cent of the cells are pathological. A careful search of the whole field at low magnification is essential for the diagnosis of tuberculosis and reticulosis their distinction depends on cytological details which may require the oil immersion lens. In all cases diagnosis depends on the finding of pathological cells and differential cell counts are not helpful. Smears are most easily interpreted by those experienced in bone marrow examination they give better results than section in marrow lymph nodes and spleen. Histological section is almost always used for liver biopsy interpretation. Undoubtedly the two methods are complementary and for tumours in general solid pieces of tissue should be sent for section and smears made from the residue.

The site of puncture is covered with collodion on cotton wool. After puncture of tumours or lymph nodes the patient can usually return home at once. After liver or spleen biopsy firm pressure is applied to the site for a few minutes and the patient should lie quietly supine until next day

Complications recorded are few In many thousands of published cases of needle biopsy of tumours and lymph nodes there are recorded a few cases of haemorrhage, all controlled by local pressure, a few of infection and two of pneumothorax, the latter caused by penetrating the apex of the lung. There is no clinical evidence of dissemination, seeding or activation of disease and experimental evidence of this is slight unless the tumour is roughly handled or larger needles are used. Because of this danger no attempt should be made to massage the tumour to break up its substance with the tip of the needle, or to inject fluid into it.

The mortality of liver biopsy is in the region of 0 1–0 15 per cent and is almost confined to those with serious disease. Mild and transient symptoms of peritoneal irritation are common after liver or spleen biopsy upper quadrant distension, with tenderness and diaphragmatic pleurisy and pneumothorax may occur The most dangerous complications are of haemorrhage and ruptured viscus these are very uncommon if a strict technique is followed, blood examination is carried out beforehand and the intercostal route is always used. Puncture of a dilated bile duct or vascular anomaly remain the most serious dangers but are very rare. Puncture of bladder and rectum have occurred at prostatic biopsy Accidents at marrow biopsy are rare a very soft bone may be fractured or the needle may slip off hard sclerotic bone.

Tissue obtained is inadequate for diagnosis in 10 per cent or less of cases success may follow further attempts. It may be impossible to aspirate tissue from very hard tumours and for these the drill undoubtedly gives the best results.

[*The illustrations for this Chapter on Needle Biopsy were drawn by Mr F Price*]

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USE OF RETRACTORS

J H LEES FERGUSON, M.B E F R C S

Assistant Surgeon, Surgeon in Charge of Varicose Veins Clinic, and Surgical Tutor Middlesex Hospital
Consulting Surgeon St. Saviour s Hospital

USE OF RETRACTORS

The primary purpose of a retractor is to assist exposure. Secondary aims include haemostasis, aid in dissection, protection of vulnerable structures, and the elimination of redundant assisting hands. Retractors are no proper remedy for inadequate or misplaced incisions, and no legitimate succour for inadequate anaesthesia. Retraction which has to be maintained so forcibly that the assistant becomes gravely fatigued, indicates an error in the conduct of the operation.

The two main types of retractor comprise the hand retractor and the self-retaining retractor Whenever possible, hand retraction which is adjustable and kinder to the tissues, is to be preferred to the fixed exposure obtained by self-retaining devices, though in such operations as thoracotomy anterior restorative rectal resection, laminectomy or when there is a shortage of assistance, some form of self-retaining instrument is almost indispensable.

In the following remarks and illustrations various types of instruments are described and named, though it is realized that there is considerable variation throughout Great Britain in the nomenclature, and the author would crave the indulgence of those who know the same instrument by another name.

In addition to the generally useful retractors here described, there exist innumerable instruments, particularly in the special branches of surgery designed to facilitate access to difficult regions these will be shown in the appropriate chapters.

Design of retractors

The design of hand retractors has, in the past, received less attention than it deserves.

The handle —Efficient retraction requires that the assistant s hand shall grasp a handle which fits it naturally without the hand being tightly closed. It should therefore be smooth, round and *at least 1* inch in diameter the butt being fish-tailed or up-turned to prevent slipping

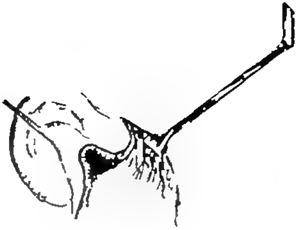
The blade —Needless trauma can be inflicted by the flat-bladed and toothed abdominal retractors, and by the use of a blade too long for the particular procedure which may press upon structures deep to the operative site (for example the spleen in gastrectomy) Over-deep retractors may also retain structures which might normally be mobilized towards the surface at a depth inconvenient to the surgeon.

The ideal retractor blade is concave fitting snugly against the abdominal wall, and is provided in several lengths and widths (The difficulty of a multiplicity of instruments has been overcome by the design of a graded set of blades, interchangeable, and fitting rigidly on to the Lloyd-Davies handle) Finally the extra-abdominal portion of a retractor should have a matt, not a polished, finish, to avoid glare, and to diminish slipping of the handle. The added illumination given by reflection from a polished blade is occasionally helpful in deep exposures.

Illumination

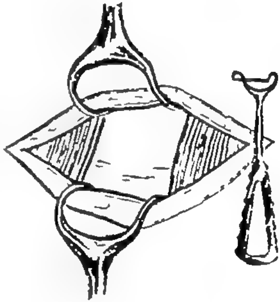
Efficient and convenient lighting in the majority of procedures is afforded by portable theatre lights with the beam directed over the surgeon s right shoulder In deep narrow wounds it is of occasional advantage to have lighting on the retractor blade itself This must be removable, easily sterilized, and placed flush with the blade surface.

HAND RETRACTORS



Skin

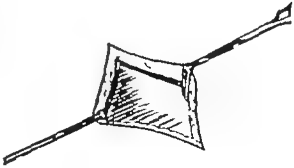
1 Minimum damage is caused by the use of Gillies skin hooks in plastic procedures. More powerful skin retraction can be obtained by the Catspaw retractor which is efficacious in reducing haemorrhage in such operations as the exposure of the parotid gland.



Subcutaneous fat and muscle (smaller wounds)

Durham's fenestrated retractors

2 Durham's fenestrated retractors are general purpose instruments, useful in retraction of the four layers of a gridiron incision. The shape of these retractors renders them only suitable for superficial retraction, particularly of rounded muscle edges or bellies. Prolapse of excess fat through the windows in small wounds constitutes an occasional inconvenience.



Langenbeck's retractors

3 Langenbeck's retractors afford a deeper narrow exposure. They are of assistance in such operations as cervical sympathectomy, exposure of the bladder neck after the retro-pubic enucleation of the prostate, and in the exploration of anal fistulae.

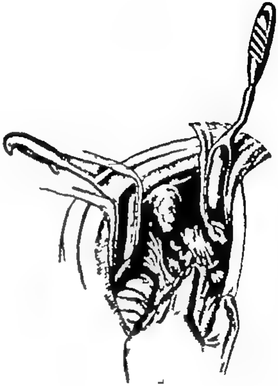
Morris's kidney retractors (which are of similar shape, but with wider concave blades) may be substituted in larger wounds. These retractors were originally designed to facilitate renal operations, but now find a place in the general set of many abdominal surgeons.

4 **Abdominal wall (extensive incisions)**

When the abdominal wall does not exceed 2½ inches in depth, Morris kidney retractors are useful all-purpose instruments. In wounds of a greater depth, the shorter Lloyd-Davies pelvic retractor or Finsterer gall bladder retractor may be used.

A very satisfactory instrument of similar type is the Proust retractor in which the handle is set at less than 90 degrees to the blade and which is made in three depths of blade.

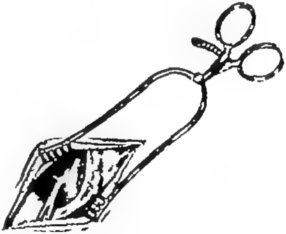
The use of the hand, Proust, and Finsterer retractors are shown in displaying the common bile duct.



SELF-RETAINING RETRACTORS

5 **Superficial layers**

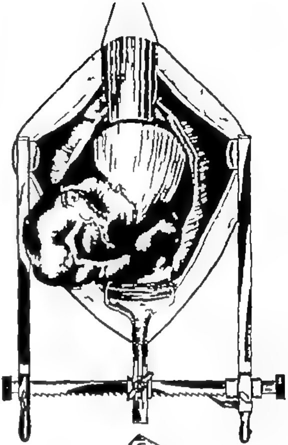
Travers or West's retractor holds back skin and superficial fascia efficiently in minor procedures such as the exposure of the sapheno-femoral junction or inguinal canal. A small disadvantage is found in the tension produced in the adjacent layers of the wound.



Retraction of viscera

6 The most efficient and gentle visceral retractor is the human hand. In situations where this is too bulky for convenience, deep in the pelvis or high under the diaphragm, a long wide-bladed retractor of the Lloyd-Davies type is used. The abdominal contents behind the blade should be protected by a swab.

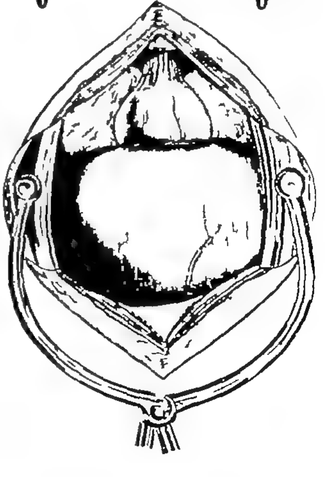
A Lloyd-Davies retractor is shown lifting the bladder up and forward. The hooked blade elevates the peritoneum of the recto-vesical pouch as this is being divided, displaying the seminal vesicles. The self-retaining retractor illustrated is a modification of Comyns Berkeley's original pattern.



The abdominal wall

7 For sub-umbilical midline or paramedian incisions (hysterectomy, retropubic prostatectomy) a Gosset's or Pozzi type of retractor is useful. The value of both these instruments is often impaired by the inadequate gap of the blades when fully opened. This should be at least 8 inches. It is a further advantage if sets of interchangeable blades of $1\frac{1}{2}$, $2\frac{1}{2}$ or $3\frac{1}{2}$ inches are available together with a pair of rake-toothed blades as used at St. Mark's Hospital in the perineal dissection of the rectum.

Wider pelvic exposure, as in synchronous combined abdomino-perineal excision of the rectum necessitates a bigger instrument such as the Comyns Berkeley retractor with a modified centre blade.



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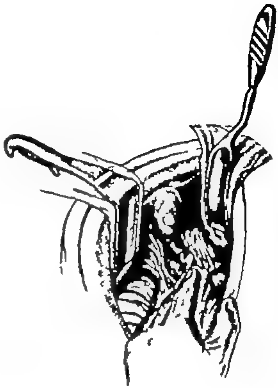

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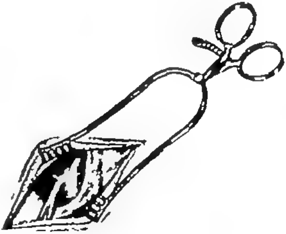

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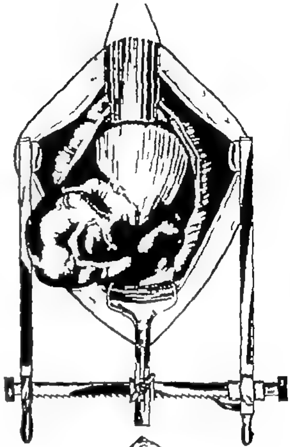

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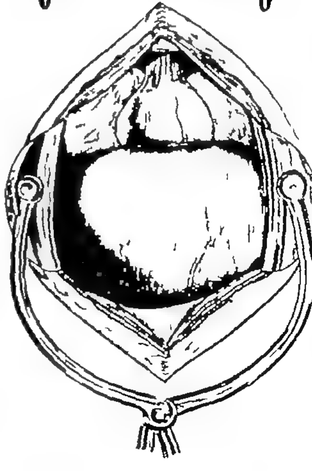
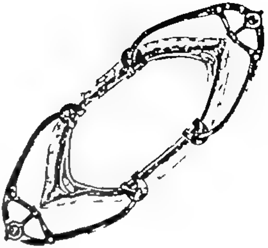


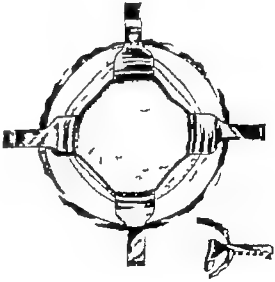
The chest

8 Rib and chest retractors must of necessity be robust in construction and so designed as to exert the maximum of mechanical advantage with the minimum effort of the operator Tuffier's retractor does not afford such a wide exposure as the Tudor Edwards or Price Thomas retractor Holmes Sellor's modification of de Quervain's instrument has excellent leverage and interchangeable blades for variation in thickness of the chest wall. The rake teeth have a rasped outer surface to prevent slipping on the retracted ribs.



Frame retractors

9 Various forms of fixed frame and ring retractors have been devised and used with success by *individual surgeons in Great Britain, namely Denis Browne and Swift Joly* These instruments are particularly applicable to the thin abdominal wall of the child, and in procedures where the operative field is static and restricted in size are of the greatest practical worth.



[The illustrations for this Chapter on Use of Retractors were drawn by Mr F Price and Mr R. N Lane]

METHODS OF DISSECTION

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PRINCIPLES OF DISSECTION

Dissection is traditionally accomplished by sharp or by blunt methods. Sharp dissection involves the use of the knife, or the cutting edge of scissors. Blunt dissection is carried out by scissors, the fingers, gauze, artery forceps, dissecting forceps, and by various types of dissector

The type of dissection which is most favoured by a surgeon depends very largely on his training and his temperament. There is little benefit to be gained by arguing the relative absolute merits of various methods, except to state that it is no longer proper to regard the exclusive use of the knife as the hall-mark of the true surgical craftsman. This attitude survives from a cruder day in which blunt dissection was synonymous with a tearing apart of the tissues or the avulsion of an organ. The scalpel is swift, elegant and non-traumatic in appropriate circumstances. Paradoxically blunt dissection may achieve a more radical extirpation in such operations as the removal of a large intra-abdominal tumour since this form of dissection can only be conducted in non-involved tissue

Expertise in surgical dissection is compounded of a mastery of all the various techniques, and of their resourceful and flexible adaptation to varying situations, rather than in a routine approach to the infinite diversity of operative problems. To this must be added the indefinable attribute of "tissue craft" a combination of innate sensibility and accumulated tactile experience essential to the elevation of dissection to an art.

Dissecting instruments

Kocher s thyroid enucleator

No surgeon would now think of using this instrument for the enucleation of the thyroid gland in the manner for which it was originally designed. It is, however helpful in isolating friable vascular leashes, in combination with the fine Vaughan Hudson aneurysm needles.

Other special dissectors include the Harold Edwards "boat and the Riches long curved dissector used in total cystectomy

Diathermy

The cutting diathermy current, passed through a sharp pointed electrode is extensively used by many British surgeons for the haemostatic and rapid division of vascular tissues, such as the intercostal muscles, the prostatic capsule and the tongue.

There is some reason to believe that impaired healing may result from its indiscriminate use. It should, further never be regarded as an essential adjunct to the surgery of carcinoma. Palliative local diathermy excision of neoplasm may occasionally be justified but in the radical surgery of cancer the surgeon should never be so near to the tumour that he takes comfort from the problematical assumption that the use of the diathermy may inhibit local recurrence

Scissors

The scissors most generally useful in dissection are the curved 6½-inch and the straight 7½-inch Mayo s scissors. MacIndoe s plastic scissors are helpful to the general surgeon in light dissection In deeper dissection in the thorax and pelvis, long-handled instruments are used, the total length being 12–14 inches. Square-ended blades maintain their alignment better and cut more efficiently

TECHNIQUE

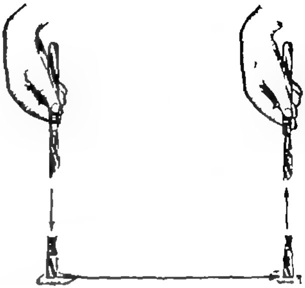
Dissection with the knife

1 The knife is employed when clean, accurate cutting of tissue with the minimum of damage is required. Division of structures or tissues which are subsequently to be united by suture should be made by the knife when possible.

The skin incision

In making a skin incision the knife is conveniently held as a violin bow between thumb and fingers, as this grip allows the maximum appreciation of touch. The blade is entered vertically into the skin and subcutaneous tissue, moved horizontally and withdrawn vertically. A lax abdominal wall will necessitate the skin being steadied, at the entry of the incision, by the thumb and forefinger of the other hand.

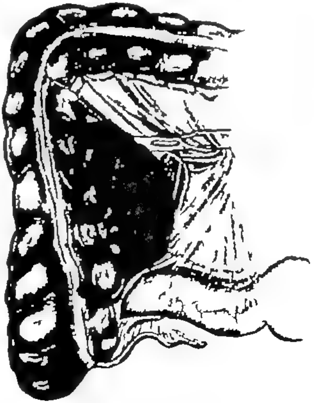
For more accurate control of the blade in further dissection the grip is changed to that used in holding a table knife, and for the finest work (such as the facial nerve in the parotid gland) a penholder grasp may be preferred.



Removal of neoplasia

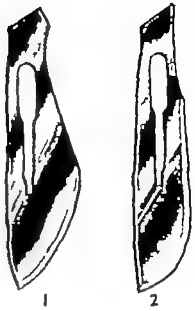
2 Other circumstances in which sharp dissection by scalpel is mandatory include the palliative resection of a neoplasm which is involving important structures, when blunt dissection may well lead to disaster. The separation of a growth of the ascending colon from the superior mesenteric vein and artery is illustrated as an example, but other situations in the neck and thorax, and in the surgery of the pancreas and pelvis, may well occur to the reader.

When it is necessary to divide resistant tissues, a scalpel forged in one piece may be substituted for the handle with detachable blade, and extra pressure without loss of control is obtained by advancing the index finger till it lies on the back of the blade.



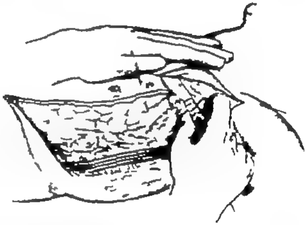
3 *Types of knife*

Except in particular manoeuvres where strength is required, the forged one piece scalpel has been displaced by the standard handle with detachable blade The shapes of blade are numerous the two commonly used by the general surgeon are shown. A more efficient shape for cutting is portrayed in (1) but (2) transmits the feel of tissue as it is being divided more sensitively



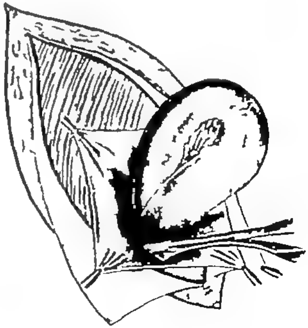
4 *Special use of the short amputating knife*

Special knives of interest to the general surgeon are the short amputating knife which may effectively be used for cutting skin flaps in a radical mastectomy



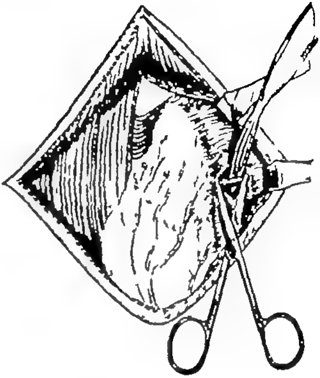
5 *The blunt-ended bistoury*

The blunt-ended bistoury finds a classical use combined with a hernia guide in the division of the neck of the sac of a strangulated femoral hernia, together with Gimbernats ligament.



Scissors

Scissors are used for elective cutting or for a combination of blunt and sharp dissection. Opening of the blades parts tissue in natural places of cleavage which may then be divided as the blades are closed.

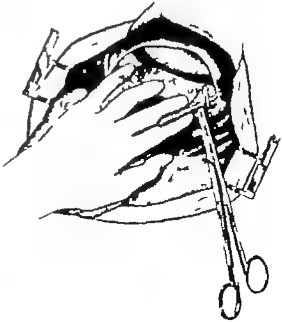


In the surgery of the thyroid gland

6 Isolation of the middle thyroid vein by Mayo's curved scissors and Kocher's dissector. The vessel is then underrun by fine aneurysm needles.

In surgery of the pelvis

The employment of long scissors, in combination with digital dissection, is essential in the pelvis where the long-handled knife cannot reach or accurately be controlled.



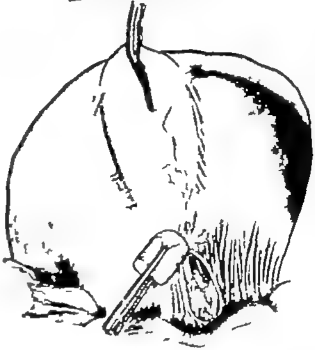
In surgery of the rectum

7 Mobilization of the rectum from above. The right lateral ligament has been defined and grouped between the index and middle fingers of the left hand, the course of the ureter having previously been traced. The ligament is then divided with Lloyd-Davies scissors.

For the mobilization of a growth frozen to the sacrum or side wall of the pelvis, the massive Tom Jones scissors are used.

Blunt dissection with the fingers

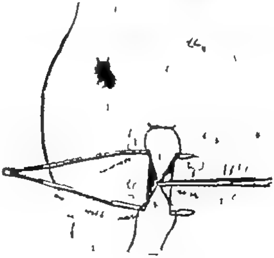
8 As a blunt dissector endowed with tactile sense the finger is invaluable on innumerable occasions such as the opening of abscesses, mobilizing growths of oesophagus or rectum, in the enucleation of the prostate or in the gentle separation of adhesions. It is surprising that its use is sometimes forgotten.



Gauze

9 The cleaning of a hernial sac by gauze stripping is a familiar example of this material's use in blunt dissection.

Small pledgets of gauze or dental felt rolls held in artery forceps form an excellent means of removal of vascular fatty tissue from such structures as the common bile duct or axillary vein without troublesome minor bleeding.



Blunt dissection by forceps

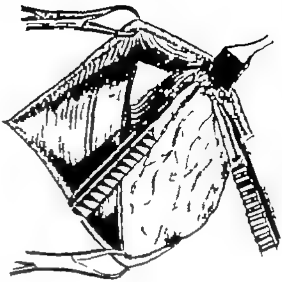
Soft-tissue separation

10 Dissecting forceps may be used for soft tissue separation by virtue of the spring of their blades. The omentum may, for example, be divided in this way into convenient leashes for ligation.

Teasing or divulsion

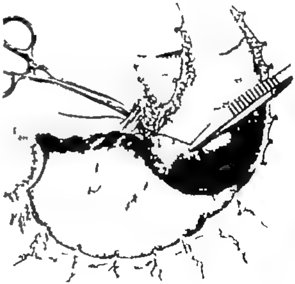
11 Two pairs of dissecting forceps may also be employed for dissecting by teasing or divulsion. This technique may be helpful in the separation of the true from the false capsule of a vascular thyroid gland.

A similar technique may be adopted in stripping and cleaning a hernial sac, where use of the forceps, aided by an occasional touch with the knife, will avoid undue bleeding. Vascular pedicles may also be defined by this method, and the mucosa of the pylorus may be then separated in Bancroft's operation.



Artery forceps

12 Artery forceps are widely used for blunt dissection and for the exposure of vessels lying in fatty or areolar tissue. The curved forceps are most convenient for this form of dissection, the points of the jaws being sufficiently fine to cause the minimum of trauma as they are opened parallel to the vessels. When each side of a pedicle has been stripped, the closed forceps are passed behind the leash and gently opened. The same forceps may then be used to clamp or to withdraw ligatures behind the isolated pedicle. Ideal for this form of dissection are tonsillar artery forceps, though within the abdomen a longer instrument will often have to be used, such as a finer variety of Moynihan forceps, or the long Lloyd-Davies forceps.



[*The illustrations for this Chapter on Methods of Dissection were drawn by Mr F Price*]

DRAINAGE

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PRE-OPERATIVE

Definition

Drainage is the surgical method of relieving or preventing the noxious deep seated accumulation of pus or any other fluid by allowing it to reach and discharge from the surface of the body or into a hollow viscus such as the rectum from which it can be evacuated. Thus, although the drainage of pus from abscesses is the commonest surgical use of drainage, the term is also used for the surgical deflection of natural body secretions and fluids from their normal paths of discharge (for example, suprapubic drainage of urine, drainage of bile by T-tube from the common bile duct). In addition pleural drainage is essential after any thoracic operation in which the lung has been punctured or a doubt exists as to the security of a suture line on a bronchus without drainage a tension pneumothorax may develop and lead rapidly to the death of the patient. The drainage of urine by a suprapubic cystostomy and similar procedures where a hollow viscus has been drained are discussed in the appropriate chapters and not here.

Securing the drain

In all cases except those in which a suprapubic area has been drained the drainage tube should be securely fixed either to the skin or other adjacent structure. Omission of this step results in the loss of the drain usually externally but sometimes internally into the abscess cavity

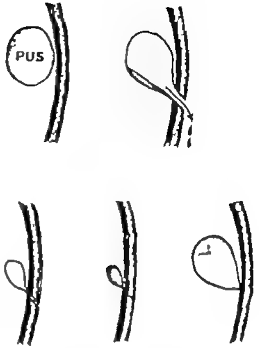
The removal of the drain

The time to remove a drain from an abscess cavity is when the cavity drained has been completely obliterated. If it is removed before this, the abscess will recur In most cases this time is adequately shown by the cessation of all discharge and the disappearance of all the local signs. However in certain deep seated abscesses (particularly empyemas and subphrenic abscesses) it is better to follow the obliteration of the cavity radiologically by periodically filling it with a contrast medium such as lipiodol and taking x-ray photographs.

TECHNIQUE

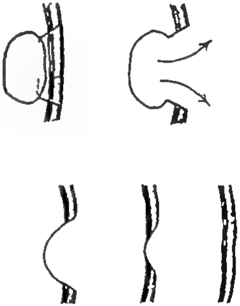
Access

1 Surgical incision to the pus or fluid to be drained must be as direct as possible. Once the cavity containing the pus has been opened, and the pus let out, the incision (if a small one) tends to heal before the cavity obliterates and *the pus then reaccumulates, leading to a* recurrence of the abscess.



Prevention of accumulation of pus

2 This can be prevented in one of two ways. (1) By making the incision so large that it cannot possibly heal before the cavity has obliterated. This principle is often used in the treatment of peri-anal abscesses—where the abscess is literally "de-roofed" (2) Much more commonly it is prevented by the insertion of a drain. Thus, the next principle of drainage is that once the cavity has been opened a foreign body must be inserted along the track of the incision to keep it open until the cavity drained has obliterated (or is able once again to discharge along its natural path, in the case of draining the urinary tract or biliary tract) The foreign body is the drain, and the exact type of drain to be used, its position and when to remove it, are problems of great importance in the management of surgical cases.

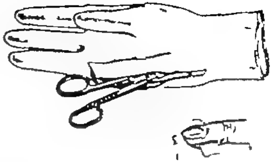


The drain

Almost any foreign material will act as a drain, but rubber is the most generally used and satisfactory as it does not adhere to the tissues. It is used in three forms

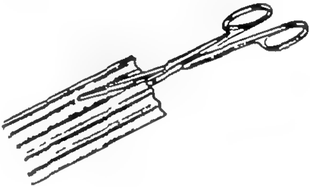
Glove rubber

3 A strip of glove rubber is thin, flexible and soft, and is best used for draining subcutaneous abscesses and whitlows of the fingers. Its softness makes it valuable for drainage of whitlows—where a hard rubber drain might ulcerate through into a tendon sheath.



Corrugated rubber

4 Where a stiffer strip of rubber is needed a drain cut from a sheet of corrugated rubber is used. This type of material is most useful for draining any surgical wound, or rather more deep seated abscesses.

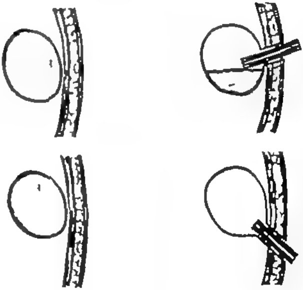


A rubber tube or catheter

This is used when a large quantity of pus or fluid has to be drained, and where the discharge of pus or fluid is likely to go on for a considerable time. By means of the tube this fluid can often be led to a receptacle.

The placing of the drain

5 Wherever possible the drain should be placed at or near the bottom of the cavity to get dependent drainage. This is a principle which should always be aimed at—although the place where the abscess finally obliterates may not necessarily be its most dependent position.



In empyema

6 This is often true of empyemas, so that in these cases the drainage tube may actually have to be lengthened to follow the contraction of the cavity

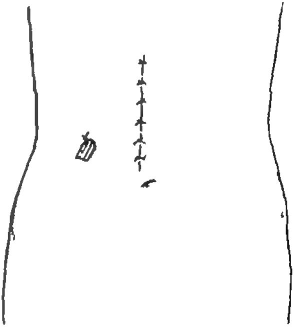
Post-operative drainage of wounds

7 After certain operations on particularly vascular parts or organs, there is a risk of haematoma formation in the wound after closure. For this reason a corrugated rubber drain is left in the wound, either emerging through one end of the original incision or through a separate stab incision. Operations on the very vascular areas, such as the face, neck and the thyroid, are best drained in this way. Blood and serum may ooze from the drainage track on to the dressings, thus preventing the formation of a haematoma. Such drains should always be removed after 2–3 days, at the longest, otherwise they may form a tract for letting infection into the wound.

Insurance drainage

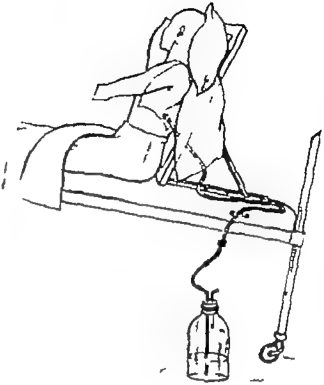
8 After certain operations a drain is placed leading down to an area or organ which might occasionally discharge profusely in the early post-operative period.

Many surgeons recommend leaving a drain down to the duodenal stump after certain cases of Polya gastrectomy in which there has been a difficult closure of an inflamed and oedematous duodenum. Should the duodenal stump give way, most of the duodenal secretion will discharge to the surface instead of into the general peritoneal cavity. After cholecystectomy a drain is usually left down to the gall-bladder bed. This is because occasionally there are small accessory bile ducts passing direct from the liver to the gall-bladder, which may be inadvertently cut during removal of the gall-bladder. Unless a drain is left in, there may be considerable leakage of bile into the peritoneal cavity from these.



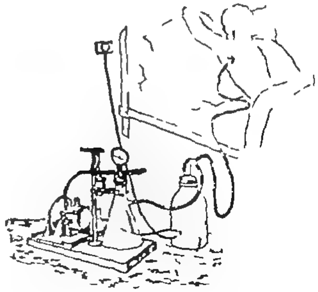
Drainage of the chest

9 Drainage of the thoracic cavity presents a special problem. In general, where drainage is indicated it must be done with a tube going to an underwater seal as shown, to preserve the negative intrathoracic pressure If this is not done, the lung will collapse. The drainage tube must be made of stout rubber or portex tubing It must not be left in for more than a week otherwise, it becomes loose in its track, and air may leak in around it, causing collapse of the lung The technique of removal of the drain is important too as it must be removed rapidly and the tract immediately closed with a stitch to prevent leakage of air into the pleural cavity



Suction drainage

10 In certain conditions fluid is best removed by continuous suction. The arrangement for suction drainage of the axilla after radical mastectomy to prevent accumulation of lymph is shown.



[*The illustrations for this Chapter on Drainage were drawn by Miss J Dewe*]

PREPARATION OF THE SKIN

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PRINCIPLES OF STERILIZATION

The whole aim of aseptic surgery is that no bacteria shall enter the surgical wound. To this end the operation is carried out in a sterile atmosphere, using sterile instruments and surrounding the wound with sterile drapes. To this point sterility can be complete but the theoretical loophole in the technique is the skin through which the wound is to be made, for this is virtually impossible to sterilize completely Fortunately this does not matter greatly The normal healthy skin produces enzymes which are lytic to most pathogenic organisms that come to rest upon it. *Even the normal healthy skin however does contain organisms in its hair follicles,* sebaceous and sweat glands but these are usually non-pathogenic, living as commensals. Thus, under these circumstances it would be possible to operate through the skin without any preparation and have the wound heal without sepsis. The trouble arises in two frequent variations from the normal.

The first is that pathogens alighting on the skin are destroyed too slowly usually because they stay in a position to which the enzymes cannot easily penetrate, for example where the skin is dirty particularly where it is hairy greasy and dirty

Secondly apparently normal people have periods when pathogens as well as non-pathogens live as commensals on the skin possibly in the follicles and glands too

It is to overcome these two variants that preparation of the skin is at all necessary and any regime must be based on removing the dirt, grease and hair that protects the pathogens from normal lytic enzymes and any antiseptic that may be painted on the skin to sterilize it.

SCHEME OF PREPARATION OF SKIN

Patients admitted for elective surgery

Whenever the conditions permit the patient should take an ordinary bath the day before operation to remove dirt and grease

Following the bath the skin over a wide area around the possible field of operation should be inspected. If still dirty or greasy it should be washed again with soap and water If hairy it will require shaving, first trimming off long hairs with clippers or scissors then shaving using 2 per cent Cetavlon as shaving lotion. The important thing is that it is done well and carefully for trauma to the skin at this time provides an opening for infection. In certain circumstances such as very nervous patients and preparation around the anus, this can only be done satisfactorily after the anaesthetic has been administered. The skin is carefully dried and no more need be done until the patient reaches the theatre on the following day After the administration of the anaesthetic, *and the patient has been fixed* in the right position for the operation, an area of at least [illegible] inches beyond any possible extension of the incision is completely cleared of gowns and sheets, and is then painted with 1 per cent Cetavlon or 1 per cent Phenoxetol in water applied on a swab in sponge-holding forceps. The area is then dried with a second swab on a holder and followed by a liberal painting of the area with 3 per cent iodine in spirit taking care to see that the whole area stays wet for 80 seconds but that the iodine does not run down creases and the sides of the patient to form pools. The purpose of this double painting is to remove grease from the superficial layers of the skin so that the iodine can penetrate to the skin itself, possibly into the hair follicles. *It has been repeatedly shown that 2 per cent iodine in* spirit will sterilize the surface of the skin in 80 seconds, and reaction to this strength tincture is very rare If reaction is feared 70 per cent alcohol alone may be used providing it remains wet for [illegible] minutes. Mackintoshes and drapes are now affixed so that the whole area for any possible incision is exposed, but with minimum spare skin exposed.

Once arranged they should be kept in position with towel clips, and if the towels show any tendency to slip the clips may be affixed to the skin If this is done, however only the finest clips (child's size) should be used for with the larger variety a painful sore will result and the patient occasionally suffers as much pain from this as from the incision.

SPECIAL PREPARATION FOR ORTHOPAEDIC AND NEUROSURGICAL CASES

Some surgeons, particularly orthopaedic and neurosurgeons, believe that greater protection against infection from the skin may be obtained by the following method.

The patient is admitted to hospital 48 hours prior to operation and the skin washed and shaved. It is then cleaned with 1 per cent Cetavlon dried and painted with 70 per cent alcohol and covered with sterile towels which are firmly bandaged in position. The towels are removed 24 hours later the skin treated with 1 per cent Cetavlon and alcohol as before and once again sterile towels are bandaged over the part. These are left in place till the patient enters the operating theatre when they are removed and the skin again painted with 70 per cent alcohol. When dry sterile stockinette is unrolled over the limb to completely cover it. The incision is made through the stockinette and the skin only after which the knife is discarded, the cut edges of the stockinette and skin are clipped together with Michell clips and the operation proceeds with a clean knife. In this way the minimum of skin is exposed to the wound, and infection should not be carried from it down into the tissues.

In places other than limbs where a stockinette roll cannot be used the part is towelled up in the normal way but the exposed skin is covered with a piece of muslin soaked in 1 in 500 perchloride of mercury so that it conforms to the contours of the part (for example the head) The incision is made through this and the skin edges clipped exactly as before.

SCHEME FOR AN EMERGENCY OPERATION

With intact skin

On these occasions there is no question of bathing and shaving the day before and often the tenderness of the injured area makes washing and shaving the un-anaesthetized patient unnecessarily painful. In these circumstances the patient is cleaned in the ward as far as possible and then taken to the theatre. When the patient is anaesthetized, but before entering the theatre, the area should be shaved as previously described. When dry any loose hair can be easily and quickly removed by applying sticky side down a wide piece of adhesive tape. The patient is then taken to the theatre and skin preparation proceeds exactly as previously described.

With an open wound

As a first aid measure the wound should have been covered with a sterile dressing and this should not be disturbed until the patient is anaesthetized and in position on the operating table. Then the bandages or strapping are cut completely away and the dressing removed with forceps If the part is hairy using 1 per cent Cetavlon as a lotion an assistant shaves around the wound, then the operator gowned and wearing two pairs of sterile gloves shaves the actual skin edges with a Bard Parker knife, moving outwards from the wound. Using several swabs one after the other from a bowl of 1 per cent Cetavlon or 1 per cent Phenoxetol in water the surgeon can thoroughly clean not only the surrounding skin but the wound itself of any macroscopic dirt. The area is dried, the operator takes off his superficial pair of gloves and towels up in the usual fashion. It may happen, as in a scalp wound, that these procedures will restart brisk bleeding In this case as soon as the wound is cleansed it should be covered with a sterile swab and pressure applied by an assistant until the towelling is complete and definitive means can be taken to stop it. It will be seen that in the presence of an open wound, no iodine or spirit is applied and reliance placed completely on Cetavlon or Phenoxetol This is because spirit or iodine coagulates exposed tissues and therefore does as much harm as good.

TECHNIQUE OF SUTURE

SKIN, FASCIA, APONEUROSIS AND PERITONEUM, VARIETIES OF STITCHING, KNOTS

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SUTURE OF SKIN

Absence of tension is the essential prerequisite for perfection in suture of the skin This must be first assured by the alignment of the original incision as nearly parallel with the lines of skin stretch (Langer s) as possible. If, owing to removal of skin, tension still exists at the conclusion of the operation, further undercutting of the flaps of skin and subcutaneous tissue must be done extension of the incision to produce rotation flaps may be necessary or a modified 'Z" plasty performed. Seldom should relaxation incisions have to be employed.

Uniting of skin edges

For the uniting of the skin edges the majority of British surgeons are agreed that interrupted stitches are superior to the use of metal clips. Sutures may be inserted by two main methods, using the finest needle and waterproof silk or braided nylon, whichever the operator feels appropriate to the region.

Subcuticular stitch

This stitch, formerly much used by the cosmetic appendicectomist, does not find favour with the plastic surgeon, principally because the apposition of the skin edges is not microscopically precise, and it has rightly fallen into comparative disuse. Its advantage lies in the fact that it may be withdrawn on the fourth or fifth day and leaves no skin puncture scars.

THE FASCIA

Superficial fascia should be united as a separate layer in the majority of wounds in order to decrease skin tension and to obliterate potential dead space in which serum or blood may collect. Suture of superficial fascia is usually carried out by interrupted stitches of fine plain catgut mounted on a round bodied half circle or J shaped needle.

When the fatty layer is not more than 1 cm. in depth, adequate co-aptation can be secured by vertical mattress skin stitches.

DEEP FASCIA AND APONEUROSIS

Effective closure is obtained by the use of single interrupted non-removable stitches of silk, cotton or linen provided that the wound is clean. A continuous non-removable suture saves time, but is open to the criticism that breakage or the cutting out of one stitch will weaken the whole wound, and that in the possible event of sepsis an extensive re-opening of the wound will be necessary A diminution of blood supply to the tissue edges is furthermore inevitable with continuous suturing Catgut used as a continuous stitch has been known to part, and should be combined with tension sutures. Closure of the fascial layer in potentially infected wounds may be accomplished by interrupted catgut stitches, or by a combination of these and tension stitches. Fascial sutures should be passed on a round-bodied needle in order to avoid cutting the fascia in the transverse line of its fibres.

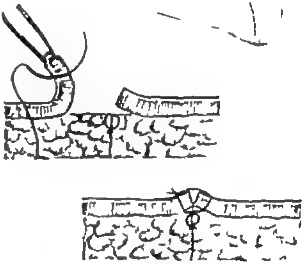
SKIN SUTURE

1 The light area represents the amount of undercutting necessary to close a wound in which there is gape due to tissue loss. If this is ineffective in relaxing all tension, then the incisions (shown dotted) are made and the undercutting extended into the darker toned area to facilitate a half rotation of each flap

Single interrupted stitches

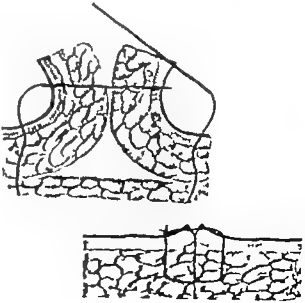
2 These are used in wounds where a cosmetic result is desirable.

The subcutaneous fascia is first united with 4/0 or 6/0 plain catgut so that the skin edges lie in close apposition. A number of 5/0 or 6/0 stitches are then inserted with a curved atraumatic or plastic suture needle held in a Gillies needle-holder the skin edge being everted by plastic-toothed forceps. Stitches are placed 5 mm. apart and each enters the skin and emerges from it at slightly more than a right-angle 2·5–3 mm. from the skin edges, ensuring eversion. They are tied very gently the knot lying over the entry puncture. These stitches are usually removed 48–72 hours after their insertion leaving the minimum of scarring



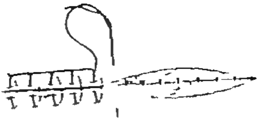
Vertical mattress stitches

3 These may be used in the closure of the majority of abdominal incisions. As the deeper bite of this stitch closes the superficial fascia, its separate suture is not mandatory though obvious dead space must be obliterated. This stitch may be inserted with a straight needle when the skin and subcutaneous fat can easily be lifted. Otherwise a curved needle must be employed. The needle enters the skin at more than a right angle, 1 cm. from the skin edge It emerges at the same angle from the other flap and is then brought back 1 mm. from the cut edge of the dermis which it traverses. The stitch should be tied with light tension, giving completely accurate apposition, and will usually need to remain *in situ* for 5–6 days.



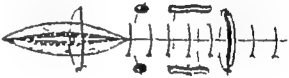
Continuous suture

4 The only advantage offered by continuous sutures is in rapidity of insertion. They impair the blood supply to the skin edge more than interrupted stitches, and do not easily permit of release of minor localized wound infections. Apposition is seldom as accurate with continuous suturing except by the continuous interlocking vertical mattress stitch (blanket stitch)



Tension stitches

5 Tension stitches of various designs may be used to reinforce the fascial layer of any wound closure. They are indicated in patients whose healing powers are suspect by reason of age cachexia, cortisone, carcinomatosis, liver disease or obesity or in patients who may be expected to subject their abdominal wall to excessive strain by coughing during the first few post-operative days. Various types are displayed in the accompanying diagram. The figure of eight stitch shown on the left of the incision is the most effective



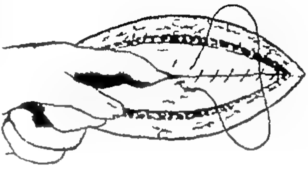
Stitch sinus and abscess

6 When localized infection develops in the deeper layers of a wound, non-absorbable suture material acts as a foreign body and sinus formation is the sequel. The offending stitch must be removed before healing can take place. This may be accomplished in *many instances by the use of a fine crochet* hook, the tract being afterwards cauterized by silver nitrate fused to a silver probe

Should this manoeuvre fail the tract must be laid open and the stitch sought under direct vision.

PERITONEUM

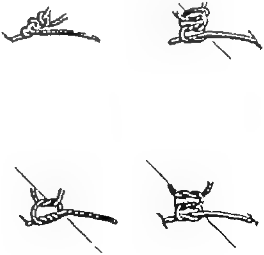
7 Perfect and sound apposition of this layer is of the greatest importance in preventing any possibility of wound dehiscence Good relaxation of the abdominal wall is essential If the peritoneal edges still fail to meet without tension the peritoneum must be mobilized from the abdominal wall by finger dissection Although many operators use non-absorbable material for suture of this layer with good results, fine chromic catgut would seem theoretically preferable, and is used by the majority of surgeons. This may be mounted on a half circle fine round-bodied needle, or ideally on an atraumatic needle. The stitch employed is a simple running suture. If splitting of the peritoneum occurs the co-operation of the anaesthetist should be sought, and a continuous horizontal mattress stitch may be substituted. Before the suture is completed, the integrity of the suture line should be tested by passing a finger along the whole of its intra-peritoneal length. Further supporting stitches should be inserted if necessary



KNOTS

8 All ligatures and sutures not subject to tension (with the exception of monofilament nylon) may be safely tied by three half-hitches with alternating crossings, or by a reef and half-hitch.

9 For sutures subject to tension and for the ligation of large vessels, the surgeon s knot or the double reef are essential, and monofilament nylon should also be tied in this manner



Tying of knots

Using the hands

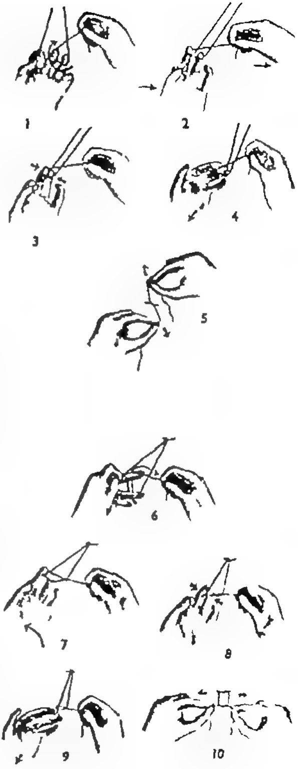
10 The most safe and secure knot is tied by the use of both hands. Each half of a reef knot, or each half-hitch must be pulled with the same firm tension.

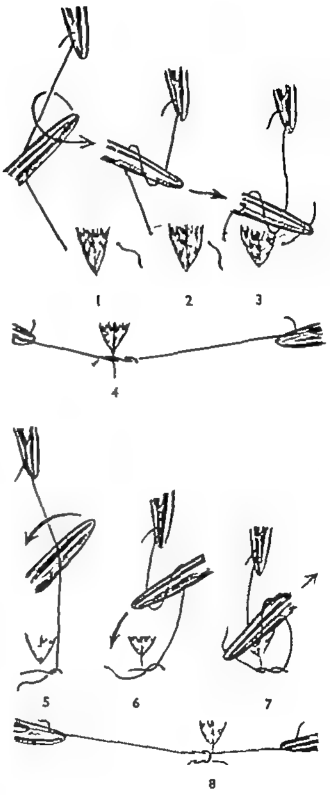
In one-handed knotting proficiency with the left hand is a useful accomplishment, allowing the long end of the suture with the needle or needle holder to be retained in the right hand throughout.

The basic method here illustrated is one of many and countless better individual modifications exist, many of which are unrecorded. Whatever technique is adopted, it is essential that the tension be maintained uniformly without relaxing the grip on either strand of the suture.

1 The short end of the suture is held between the left thumb and forefinger while a loop is passed across the pulps of the opened middle and ring fingers, in clockwise direction, the palm being upwards.
2. The short end is swung across to overlay the finger loop, the right middle finger being flexed back.
3. The short end is grasped between the middle and ring fingers.
4 The short end is withdrawn whilst tension is maintained by the right hand.
5. The left index finger and thumb again take up the tension, and the hands are crossed to tie the first half of the reef knot
6. The short end is held by the left thumb and index finger but the palm now inclined downwards, and the right hand loop is thrown across the pulp and dorsal aspect of the left ring finger and across the dorsal aspect of the middle finger so that the strand held in the right hand is behind that which runs from the ring finger to the knot.
7 The short end is laid over the loop 8 and 9 and withdrawn by the middle and ring fingers.
10 The second half of the knot is tightened by crossing the hands

One useful modification of the technique as depicted here is the conjunction of the right little finger which enables continuous tension to be maintained with greater delicacy





Tying by instruments

11 Knot tying by instruments was formerly an essential feature of "no-touch" technique. Though this is very rarely considered necessary to-day instrumental tying is frequently dictated by reasons of access, for example, at the bottom of a deep wound. The dissecting forceps most suitable for this form of knotting has an apposing roughened plate situated immediately proximal to the teeth which grasps even the finest suture firmly.

The series of movements illustrated are largely self-explanatory as far as it lies in the power of two dimensional diagrams to demonstrate complex movement, though the reversal of the needle holder point is not so complete as it would appear from the transition between 5 and 6.

The surgeons' knot can be quickly tied by instruments, a double loop being thrown over the needle holder in 1 and 2. The same direction of throw as in 1 and 2 is then repeated in movements 5 and 6.

ACKNOWLEDGEMENT

The author would wish to record his gratitude to Mr. R. S. Sampson Handley for his invaluable help.

[*The illustrations for this Chapter on Technique of Suture were drawn by Mr. F. Price.*]

RADIUM NEEDLE INSERTION

W H Bond F R C S., D M R T

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PRE-OPERATIVE

Indications

Radium needle insertion or implant is most frequently done for tumours of the mouth and is the treatment of choice for epithelioma of the tongue and buccal mucosa. The method is also of value in the treatment of carcinoma of the maxilla, the ethmoid region and nasal cavity and of the larynx, all requiring specialized techniques of insertion. Squamous carcinoma of the skin is occasionally treated by implantation and radon seeds are a useful method for small tumours in difficult sites. Radon seeds are also used in the treatment of carcinoma of the bladder and find a wide application in the management of tumours of the soft palate and fauces.

Special equipment

Radium needle introducers of straight and right angle types, double edged tenotome or Keyne s knife, Morison s forceps for the removal of needles with broken threads needle pushers, gold seed introducers.

Pre operative preparation

General measures to improve the health of the patient are important, including whole blood transfusion, antibiotics to combat chest and oral infections, and a high protein diet suited to his masticatory powers. Where a skin surface is to be implanted irritation must be avoided and no antiseptic containing iodine or mercury applied. Dental hygiene is important where a mouth implant is to be done, and the majority of patients require complete clearance of teeth. Where the teeth are more satisfactory scaling and extraction of carious and filled teeth may suffice. Extraction with elevators minimizes bone damage and careful gum suture promotes healing so that implant can usually be done in 7 days. Implant of needles and extractions should never be done at the same time

A plan detailing the strength, linear intensity and site of every needle is worked out, usually aiming to leave the needles *in situ* for a week to deliver a dose of 6 000–7 000 roentgens at 0·5 cm. from the radium needles.

Anaesthesia

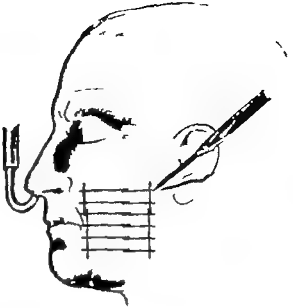
General anaesthesia with tracheal intubation is required for accurate work in any part of the head and neck. Local anaesthesia may be used for minor skin lesions.

Position of the patient

The position must be as natural as possible when implanting any mobile part so that the needle distribution is not distorted on recovery from the anaesthetic When implanting the tongue the pack should be carefully placed using the minimum of material. Implantation of the cheek should be done with the mouth almost closed so that the tissues are not stretched. On those rare occasions when anus, perineum or vulva are implanted the left lateral or Sim s position should be used and when the breast and axilla are implanted the position should be one of comfort which can be readily adopted on recovery from the anaesthetic.

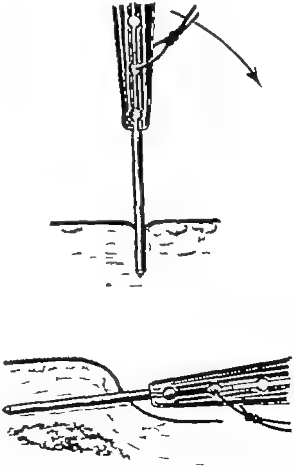
THE OPERATION

FOR EPITHELIOMA OF THE BUCCAL ASPECT OF THE CHEEK



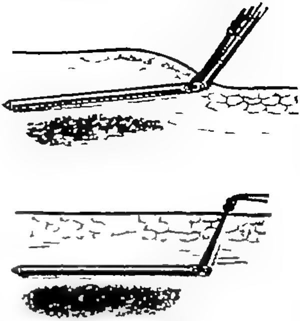
Plan for insertion of needles

1 The plan is copied on to the skin using a sterile ball point pen and metal ruler measuring each dimension accurately. Radium needles will not penetrate normal skin, so a fine puncture wound is made at the point of entry of each needle, using a tenotome or Keynes's knife. Insertion is simplified and the implant is more accurate if needles are inserted from the periphery towards the midline.



Insertion of the needle

2 The needle, threaded with strong silk, stainless steel wire or nylon thread and held in special grooved holding forceps, is inserted in two distinct movements. The first, perpendicular to the skin, carries the point to the required depth, in this case into the sub-mucosa. The needle axis is then turned through 90 degrees and, paying attention to the surface plan, pushed firmly through the tissues, directed by a finger on the mucosa until all but the eye is buried. All needles are inserted in this manner so that they can be seen to lie parallel, and to avoid unnecessary exposure to the directing finger the anterior needles are the last to be inserted.



Final positioning

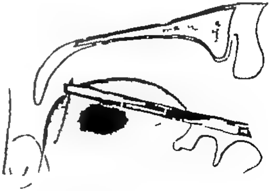
3 Using a suitable pusher the eye and thread are buried so that the needle lies as was planned. The parallel needles filling the centre of the implant should be fully inserted before the crossing needles at the ends of the implant are inserted.

Retaining sutures

4 The loss of a single needle destroys the value of an implant and the minor disfigurement of a skin suture to hold the skin threads is unimportant. No dressing need be applied though collodion can be used to close the skin punctures. The patient is kept under the anaesthetic while a radiograph is taken to confirm the accuracy of the implant should any needle be in a bad position, reinsertion is done and the position checked by further radiographs before the patient is returned to the ward.

IMPLANTATION OF THE TONGUE

Placing of needles



5 *Implant of the tongue for epithelioma presents* a number of difficulties if bunching of the needles is to be avoided. The throat is packed very lightly so that distortion of the tongue does not occur and for the same reason, in spite of the difficulties imposed, the tongue is not pulled out of the mouth or distorted by *metal retractors during the operation.* The first needle to be inserted is always the most posterior and this must be directed backwards at an angle of 20–30 degrees, leaving about 0·75 cm exposed at this stage

Succeeding needles

6 Succeeding needles are directed more vertically, gradually pointing forwards as the foremost needles are inserted. When all tension on the tongue is relaxed and if the angles of insertion have been well chosen, it will be found that all needles are vertical and parallel as can be judged from the short length standing above the surface of the tongue.

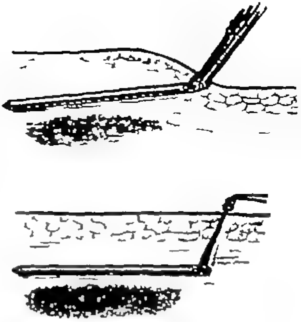
Final positioning

7 When the vertical position of the needles is satisfactory they can be pushed below the surface of the mucosa, using a right-angle pusher and the final crossing needle inserted to be level with their eyes. It is common practice to suture the needles in place using an additional thread through the eye, though it is doubtful if this gives much additional security. Radiographs are taken, any corrections made and finally the threads are drawn through a short length of Pauls tubing to be secured by a stitch to the skin. When the anaesthetic is discontinued any airway should be inserted with great care to avoid disturbing the implant.

CARCINOMA OF THE LARYNX

The incision

8 The incision is crescentic, situated over the lateral aspect of the thyroid cartilage extending from the superior horn downwards and forwards to overlie the anterior part of the cricoid.



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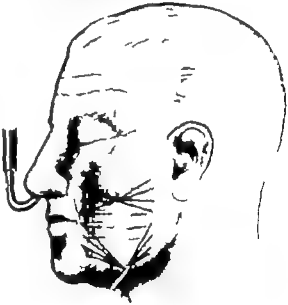

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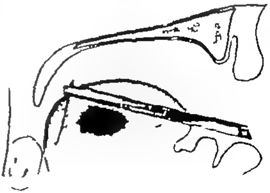
IMPLANTATION OF THE TONGUE



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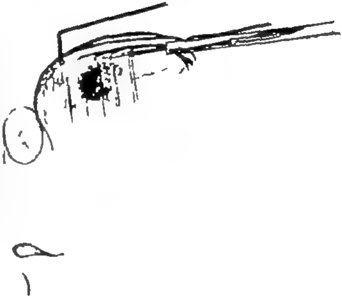


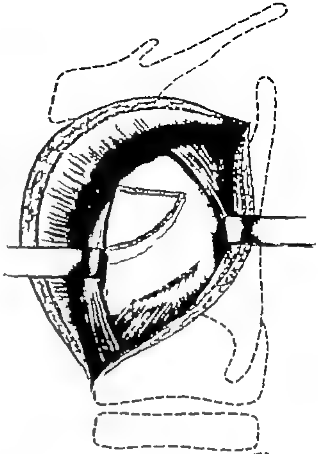
CARCINOMA OF THE LARYNX

The incision

8 The incision is crescentic, situated over the lateral aspect of the thyroid cartilage extending from the superior horn downwards and forwards to overlie the anterior part of the cricoid.

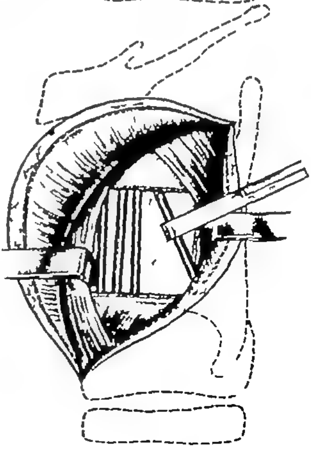
The exposure

9 The incision is deepened and a flap reflected forwards containing skin superficial fascia, and the platysma. The sternohyoid muscle is split to expose the ala of the thyroid cartilage, the sternothyroid and thyrohyoid muscles are detached from the oblique line of the thyroid cartilage and retracted backwards. The outer perichondrium of the thyroid cartilage is then reflected, and taking care to avoid damage to the mucoperiosteum, the ala is nibbled away over an area of approximately 2·0 × 2·5 cm. the upper and lower margins being left intact.



Needle insertion and closure

10 The mucoperiosteum at the upper and lower margins is separated from the cartilage and a vertical palisade of 6 7 or 8 needles inserted into the sulcus so formed. The needles will remain *in situ* without fixation though in other techniques when fewer needles are used they may be attached to a rubber sheet or wired together with silver wire. The needles each carry 1·0 mg of radium and have a wall thickness of 0·6 or 0·8 mm of platinum. Closure is effected with catgut sutures approximating the muscles, silkworm gut to the skin, no drain being required. Six, seven or eight days later depending on the number of needles used, the wound is reopened, the needles removed, the wound closed with a small rubber drain left in for 48 hours.

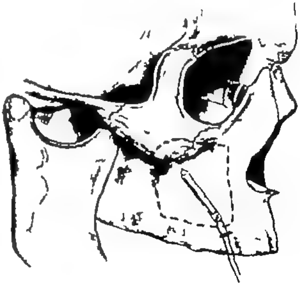


CARCINOMA OF THE MAXILLA

11 This is a simple method of treatment for maxillary and antral carcinoma suitable for early and many late tumours, the best results being obtained when the tumour is confined to the antrum or involving only the lateral walls. When the ethmoid region is involved additional needles can be inserted though this class of case is probably best managed by external radiation. In the advanced case the needle may be inserted directly into the tumour but in earlier cases—as illustrated—the cheek is retracted laterally and an incision made into the mucosa of the canine fossa. Mucosa and periosteum are reflected and the antrum opened if necessary with drill or chisel.

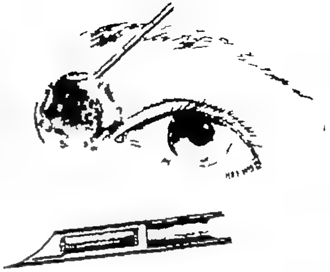
Needle insertion

12 A radium needle is inserted directly into the estimated centre of the growth where it is usually held firmly though when the antrum is not filled by tumour a radium tube enclosed in a rubber sheath may be more secure. Two threads from the needle or tube are brought out, passed through the full thickness of the cheek and tied over a small piece of rubber tube. There is, however considerable risk of implantation of malignant cells if the needle is passed from mucosa to skin surface This risk is reduced if the stay suture thread be passed twice from skin to mucosa using a separate needle for each traverse of the cheek. The radium content is usually 2·5 mg the needle is removed without anaesthesia after 4–7 days, depending on the size of the tumour and the dose level required



RADON SEED INSERTION

13 Radon seeds consisting of a minute quantity of radon gas sealed in gold capillary tubing 0·8 or 0·6 mm. thick and 0·0 mm. long are inserted with a suitable needle and plunger or Souttar's gun. The operation is done under a local anaesthetic, the needle being inserted without preliminary skin incision and the seed remaining permanently *in situ*. A rather larger seed screened with platinum and attached to thin silk thread may be used where it is desirable to remove the seeds. In either case preliminary physical planning and accuracy of implant are essential for consistently satisfactory results.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

During recovery from the anaesthetic constant watch must be kept to avoid the needles being pulled out and to maintain the airway where an oral implant has been done. An initial dose of morphine may be required but severe post-operative pain is exceptional.

Oedema and haemorrhage

Some swelling of the implanted region is usual and in the mouth may result in feeding difficulties requiring pharyngeal or nasal intubation. Haemorrhage may occur when the needles are removed but usually ceases with simple measures; sutures should only be used to control bleeding as a last resort.

Removal of needles

The time of removal of the needles is determined by calculations from post-operative radiographs. No difficulties are normally met if the pull is made in the long axis of the needle.

Skin and mucosal reactions

These are a normal consequence of implant and are unavoidable. Skin reactions should be kept dry; aspirin is the most useful mucosal sedative and the reactions subside in 6–8 weeks.

[*The illustrations for this Chapter on Radium Needle Insertion were drawn by Mr. F. Price.*]

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BURST ABDOMEN—WOUND DEHISCENCE

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PRE-OPERATIVE

Occurrence

Wounds usually burst not because they are badly sewn together but because they fail to heal by the time that the stitches are either weakening from absorption or beginning to cut through. Consequently burst abdomens tend to occur between from 6 to 14 days after operation.

The absence of healing may be due to old age, advanced general wasting disease such as carcinoma, liver insufficiency (cirrhosis) malnutrition—possibly associated with the acute disease process—extensive wound sepsis extensive wound haematoma, and the presence of enzymes (for example in pancreatitis)

Precipitating factors which alone would not cause bursting though they might lead to herniation later on are abdominal distension and severe coughing

Wound dehiscence is common in midline and paramedian incisions, uncommon in muscle cuts, rare in muscle splitting and thoracic incisions.

Symptoms and signs

Sometimes the patient has a sharp bout of coughing or vomiting, feels his wound give way and coils of gut appear from under the dressings. Frequently however the onset is not so dramatic but any of the following symptoms and signs should lead to an examination of the wound.

(a) Pain in the wound especially if this is new in development and worse on coughing
(b) Unexplained persistently raised pulse rate.
(c) Unexplained vomiting
(d) Serous or sero-sanguineous discharge from the wound.

Even when the dressing is removed, recognition may not be easy

Pre-operative preparation

First aid should be given to the wound. It is wise to pass a Ryle s tube and keep the stomach aspirated. Intravenous fluid should be given if the patient has been vomiting much, and in the unusual circumstance when shock is marked a blood transfusion should be commenced. If the patient is restless morphine should be administered.

Anaesthesia

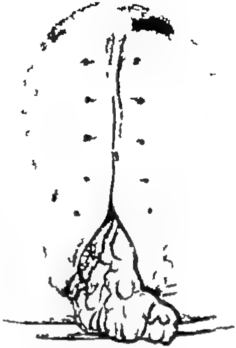
Local anaesthesia used to be recommended owing to the frail state of these patients and the tendency to vomit during induction but it is unsatisfactory as the patients tend to strain, forcing out the intestine with increased risk of damage to it, whilst the sutures placed in such difficult circumstances often cut through the friable tissues, making closure prolonged and uncertain. Today if a skilled anaesthetist is available most surgeons prefer a light general anaesthetic using relaxants, and a cuffed endotracheal tube. Then, however ill the patient, adequate oxygenation can be ensured and with the relaxation obtained the wound can be closed quickly and safely

RECOGNITION

Localized separation of the wound with a small tongue of omentum protruding

1 This may be so small that it sits within the wound and looks like a piece of subcutaneous fat. Factors in recognition are

(1) Shiny rather than covered with granulations.
(2) Definition of its sides with a probe to show that it is coming from inside the abdomen.
(3) Localized bulging of the surrounding wound.



Skin nearly intact but deeper layers separated

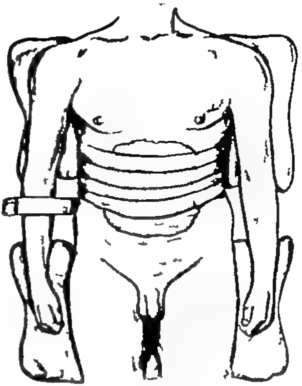
2 In this case the wound bulges and there is slight separation between the sutures from which discharges serous or sero-sanguineous fluid. A glistening bowel will be seen through the gap in the skin.

If there is any doubt a stitch or two in the suspected region should be removed, the skin edges separated and a good view obtained to see if there is any bulging bowel or omentum. No harm will be done for if the bulge is due to pus or blood it should be evacuated anyway

THE OPERATION

First aid treatment

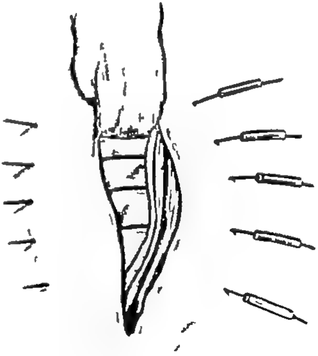
3 A firm pillow is placed under chest and another under the pelvis whilst the dressing is being applied. Large saline packs should be placed over the entire wound and extruded contents More packs of sterile cotton wool should be placed on top of this. The whole abdomen is supported by firm encircling Elastoplast bandages or a many-tailed binder

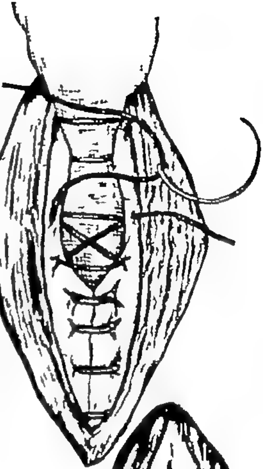


Re opening of the wound

4 The wound including any prolapsed bowel or omentum is swabbed with ample solution of 1 per cent Cetavlon or 1 per cent Phenoxetol in water The skin stitches are removed. The extent of the burst is ascertained. It is nearly always greater than expected. The wound is opened until firm healing parts are reached. The extruded gut is gently swabbed with saline solution and carefully examined for damage caused by clips. If present, any lacerations must be repaired or any greatly damaged parts resected. The gut and omentum is then returned to the abdomen, and kept in position by a moist pack of sufficient size to allow eversion of the whole thickness of the wound edge without allowing the gut to escape Using a large half-circle cutting needle a stitch *of some strong non-absorbable material* such as No. 3 waxed braided silk is passed through all layers of the wound about 2 centimetres from the edge. The left hand lifts and everts the wound edge as this is done, to hold it clear of the underlying pack.

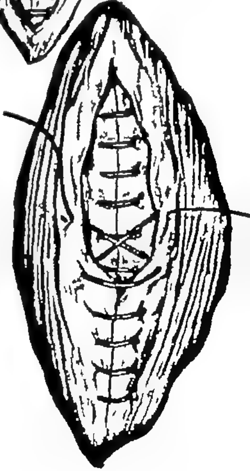
The stitch is left untied with artery forceps hanging from each end. Further sutures are placed 2 cm. apart along the length of the wound. It will be realized that there is minimal disturbance of the intra-abdominal contents.





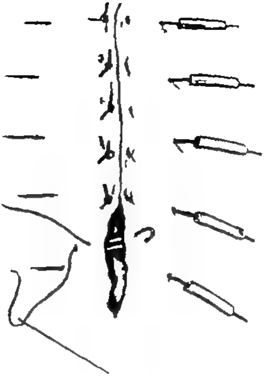
Coaptation of peritoneum and posterior rectus sheath

5 Using a somewhat smaller half-circle round bodied needle with No 0 chromic catgut, the peritoneum and posterior rectus sheath is coapted with a series of figure-of-8 interrupted sutures. This suture is recommended throughout as it has the advantage of an interrupted suture without the same tendency to cut out. If the tissues are so softened and cheesy that the stitches will not hold, a bite of muscle or even muscle plus anterior rectus sheath must be taken as well. In the latter case it will be unnecessary to sew the anterior rectus sheath separately. These figure-of-8 sutures are continued 1 cm. apart until the wound is three quarters closed when the pack is partly withdrawn. Further stitches are inserted removing the pack just before inserting the last. The placing of this pack is extremely important. It must be neatly folded to aid easy withdrawal but it may be allowed to protrude from the top or bottom of the wound according to convenience.



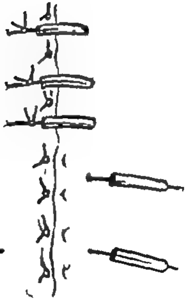
Closure of the anterior rectus sheath

6 Similar sutures using No 1 chromic catgut are placed in the anterior layer of the rectus sheath.



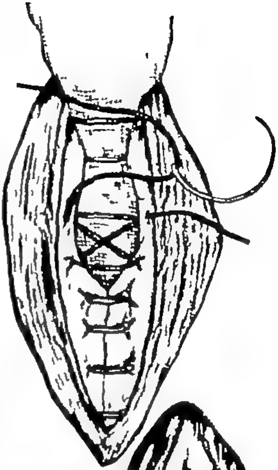
Apposition of the skin edges

7 The skin edges are brought exactly together with everting vertical mattress sutures of fine silk or nylon



Tying the "all layers" sutures

8 The "all layers" sutures are tied so that they are just tight but with no tension to avoid pressure necrosis. On occasion the wound is so soft that no buried sutures will hold. In this case the wound can be closed satisfactorily with "all layer" and skin sutures only. Ample gauze is applied over the wound, and held in place by tightly stretched transverse pieces of Elastoplast. This is to give further support to the wound and is contrary to the usual practice where the Elastoplast should be put on lightly to allow the patient to breathe easily and deeply



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Coaptation of peritoneum and posterior rectus sheath

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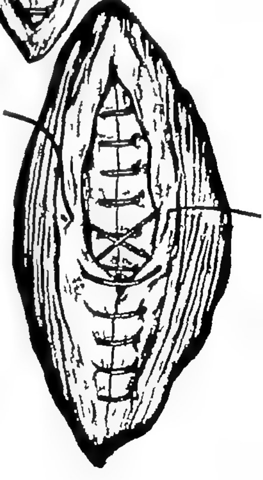


6

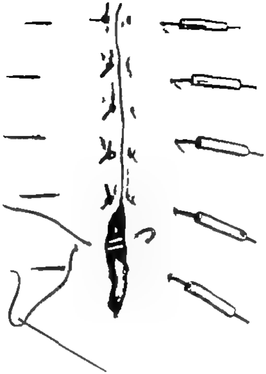
Closure of the anterior rectus sheath

Similar sutures using No. 1 chromic catgut are placed in the anterior layer of the rectus sheath.

7

Apposition of the skin edges

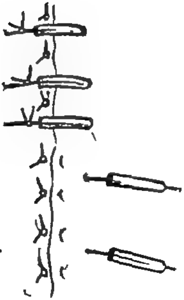
The skin edges are brought exactly together with everting vertical mattress sutures of fine silk or nylon



8

Tying the "all layers" sutures

The "all layers" sutures are tied so that they are just tight but with no tension to avoid pressure necrosis. On occasion the wound is so soft that no buried sutures will hold. In this case the wound can be closed satisfactorily with "all layer" and skin sutures only. Ample gauze is applied over the wound and held in place by tightly stretched transverse pieces of Elastoplast. This is to give further support to the wound and is contrary to the usual practice where the Elastoplast should be put on lightly to allow the patient to breathe easily and deeply



POST-OPERATIVE CARE AND COMPLICATIONS

This is partly dictated by the original pathology but should follow these broad lines. Hourly gastric aspiration and 2 fluid ounces of water given hourly by mouth until bowel sounds are present and a positive fluid intake is obtained. Intravenous fluid and electrolyte requirements should be estimated and the necessary replacement carried out. *Transfusion with 1 pint of blood is usually necessary but if the patient is anaemic or in a bad state of* nutrition more may be required to obtain satisfactory healing. Small regular doses of morphine by intramuscular injection should be given. The patient should be given vigorous respiratory exercises and encouraged to expectorate. Any sepsis present must be combated with appropriate antibiotic therapy. A full protein and vitamin diet is necessary and this should be achieved as soon as possible. As soon as his intra-abdominal condition permits the patient can be allowed to sit upright in a chair.

The wound usually develops considerable swelling and redness but heals satisfactorily when alternate sutures should be removed on the twelfth day and the remainder 2 days later. Sometimes pus collects in the wound and must be drained by removing the minimal number of stitches to obtain free drainage with minimal loss of support to the wound. On occasion sepsis is so severe that the sutures lie practically loose. They should be retained as long as they are of some use in supporting the wound. But this must be reinforced with adequate Elastoplast corsetage. A second complete burst is unusual as the peritoneal layer usually holds firm and once the sepsis is overcome the slough separates and the wound can be allowed to granulate with daily Eusol in paraffin dressings. Secondary suture is generally not advised. Should the wound completely burst a second time it will then be closed with "all layer" and skin sutures only.

Before discharge from hospital these patients should be fitted with a good abdominal support because they frequently develop an incisional hernia and a support will limit the extent of this.

[The Illustrations for this Chapter on Burst Abdomen—Wound Dehiscence were drawn by Mr. R. Foster.]

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PART II

SURGERY OF TRAUMA

PART II SURGERY OF TRAUMA

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EXCISION OF SOFT TISSUE WOUNDS

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PRE-OPERATIVE

Excision of wounds may be defined as the cutting away of all grossly damaged, devitalized, and contaminated tissues which form a suitable medium for the growth of organisms, together with the removal of all easily accessible foreign bodies which may be the source of continued infection.

The aim of wound excision is to prevent a contaminated wound becoming an infected one, and by the relief of tension to preserve the vitality of surrounding tissue and thus obtain healing in the shortest possible time, either by primary, delayed primary, or secondary suture.

Indications

All wounds which are grossly contaminated with dirt or other embedded foreign materials, especially those with severe muscle damage, should be excised. Dead and damaged muscle produces shock and is an ideal medium for the growth of organisms, particularly those which produce gas gangrene. The sooner a wound is excised the better.

Contra indications

War experience has taught that wounds should not be excised if more than 8 hours have elapsed since the wound was inflicted. After this time, infection may be considered as already established and to excise such a wound will spread infection and neither limit nor prevent it. Simple wound toilet should then be practised and the wound treated as an infected one.

Pre operative preparation

The surgeon should gain the patient's confidence and make him comfortable. The severity of the wounds should be assessed, taking note especially of the degree of muscle damage. Haemorrhage must be arrested and the patient treated for shock.

Severe limb wounds produce shock because of their major muscle damage. This may be measured in volumes equivalent to that of the closed fist. Any wound with more than three fist volumes of muscle damage will require urgent transfusion. Shock has not been overcome, nor fluid loss sufficiently replaced, until the systolic pressure has been restored at least to 100 mm. of mercury. The sudden loss of 3 pints of blood reduces the total blood volume to the critical level of 60 per cent. One pint of transfused blood will raise the blood volume by 10 per cent and the haemoglobin by roughly 7 per cent.

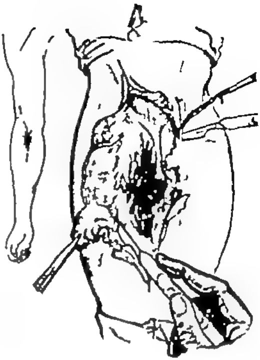
Any pain present must be relieved and two-plane radiographs taken to show the damage to bone and the location and number of the radio-opaque foreign bodies. Before anaesthetic premedication, antibiotics should be given as well as prophylactic antitetanus serum.

It is imperative to resuscitate a patient before operation except when haemorrhage cannot be controlled or compensated for by transfusion, or when muscle damage is severe and toxic absorption too great to be overcome until the dead tissue is excised.

Anaesthesia

Usually general anaesthesia is advisable. Occasionally the limb may be blocked by local anaesthetic, for example brachial block.

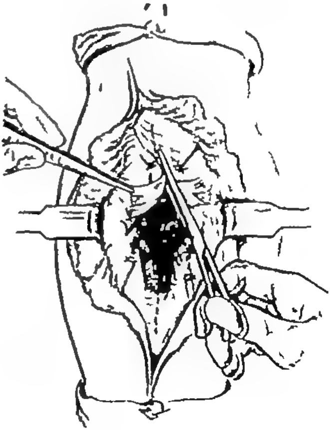
The patient is placed on the table in a position which gives easy access to the wound. Whilst the wound is protected with a swab, a wide area of the skin surrounding the limb, above and below the wound, is shaved and cleaned with a detergent, dried, painted with antiseptic and isolated with sterile towels.



THE OPERATION

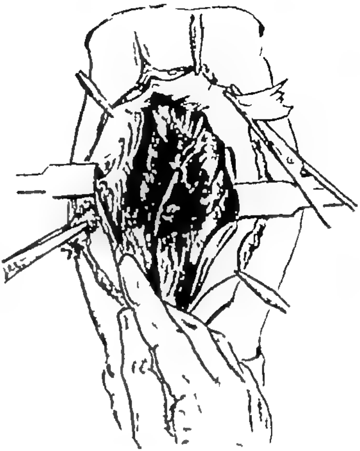
Enlargement of wound

1 The wound is enlarged above and below by skin incisions in the long axis of the limb These should be curved if they cross a joint crease. Living skin is the best possible cover for a wound. It is also the most viable and infection-resisting tissue Only dead skin is excised with a sharp knife or scissors, and it is bad surgery to sacrifice viable skin because it is bruised and discoloured.



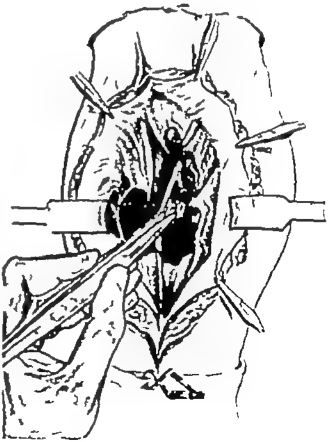
Incision for access to depths of wound

2 Superficial haemorrhage is arrested by ligatures. The deep fascia is incised in the long axis of the limb to the limits of the skin incision. This relieves tension and allows easy access to the depths of the wound. Incisions at right angles to the direction of its fibres may be necessary to allow for adequate decompression



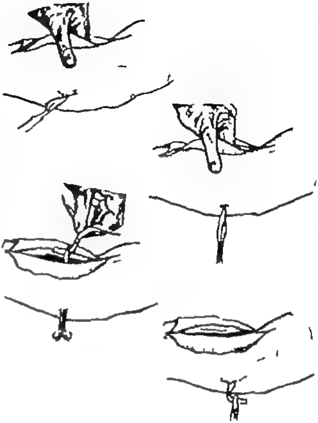
Removal of fascial edges and deep exposure

3 Tattered fascial edges are excised and the depths of the wound are widely exposed. Discoloured muscle which does not bleed or contract is generously removed with a sharp knife or scissors. It is important to identify all vessels nerves, and tendons, carefully preserving all those that are uninjured and recording the fact.



Removal of foreign bodies

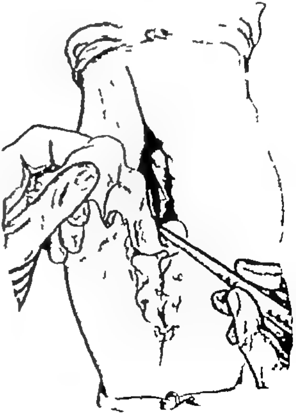
4 All grit, dirt, bits of clothing and other easily accessible foreign bodies are removed. It is preferable to remove foreign bodies *via* their track of entry. Occasionally it is advisable to remove them through a separate incision over them. All clots are evacuated. The minimum number of ligatures should be left in the depths of the wound. Injured vessels, nerves and tendons should be treated as described later.



Drainage

5

It may be necessary to drain the wound to prevent the collection of exudate or the formation of clot, or because the wound is already infected. In this case the most dependent part of the wound is sought by finger exploration and the skin incised over the tip of the exploring finger. Blunt forceps are then pressed through the tissues, preferably in an intermuscular plane, into the depths of the wound and a length of corrugated rubber or glove drain is withdrawn by the forceps leaving one end within the wound cavity and the other protruding through the skin.



Wound closure

6

At this stage it must be decided whether to close the wound by primary suture or leave it open. It may safely be closed if there is no tension and there is no doubt about excision being complete; the wound must be less than [illegible] hours old and the patient is to remain in the same hospital until the stitches are removed.

If these conditions are not fulfilled the wound is dressed by placing gauze in the wound in such a way as to prevent the formation of pockets and to allow for the seepage of exudate. The limb is immobilized in a split, padded plaster case including the joints above and below the wound.

POST-OPERATIVE CARE

On return to the ward the limb should be elevated to minimize oedema. The treatment of shock must be continued, with frequent records of the blood pressure pulse rate colour of the patient's skin, and urine output These records are maintained until equilibrium has been regained. Prophylactic antibiotics are continued.

A poor response to resuscitation may be due to continued haemorrhage the effects of some other undiscovered injury the onset of the crush syndrome or fulminating infection

The distal parts of the limb (fingers or toes) should be observed frequently to ensure that the circulation is adequate.

"If a patient in plaster complains of pain within his plaster believe him." Remove the splint and examine the limb Severe pain may mean the onset of gas gangrene.

A nourishing diet of high protein content is needed.

If progress is satisfactory in a wound not closed previously the patient is returned to the operating theatre on the fourth to the seventh day for delayed primary suture of the wound.

The suture of wounds (*See* page 10)

Primary suture

The technique is the same as for any surgical operation. It may often be practised in civil casualties provided that (1) the wound is thoroughly excised and is sterile (2) it can be done without tension (3) the patient remains in the same hospital until the stitches are removed.

In mobile warfare primary suture should never be done

Delayed primary suture (D.P.S.)

In this method the wound is closed on about the fifth day

The skin round the wound is cleaned and painted with an antiseptic solution and isolated with sterile towels. The dressings are gently removed and the wound inspected. If suitable for closure the skin edges are freshened with a sharp knife. Healthy granulations are left undisturbed. A long curved needle threaded with nylon or silk is passed through the skin and deeper tissues in such a way that when tied, without tension, it closes all dead spaces. A few intermediate stitches passing through the skin only may be needed in addition.

Delayed primary suture should not be carried out if (1) the patient's general condition is poor (2) there is any doubt about sepsis being present (3) the circulation in the limb is in doubt (4) sloughs are still adherent.

Secondary suture

Secondary suture may be performed at any time after 10 days.

The technique is the same but it may mean undermining the skin edges to allow approximation It is often wise to insert a small glove drain under the skin. In all large wounds it may be necessary to cover the defect either by the use of relief incisions, free skin grafts or pedicle grafts.

[The illustrations for this Chapter on Excision of Soft Tissue Wounds were drawn by Lt.-Col R. S Hunt M.B.E., F.R.C.S. (Ed.) R.A.M.C.]

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PRIMARY, DELAYED PRIMARY AND SECONDARY SUTURE

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PRE-OPERATIVE

The best covering for wounds is healthy skin.

Primary suture is more often possible in civilian practice than in war experience. Except in remote parts of a country civilian casualties reach hospital within 8 hours and remain under the care of the same surgeon until discharged. This does not apply in war. Evacuation along lines of communication makes early travel necessary and frequent changes in supervision therefore follow.

PRIMARY SUTURE

Indications

Primary skin suture is imperative in three situations, even if skin loss makes direct approximation impossible. (1) The scalp to protect underlying bone and damaged intracranial tissue. (2) The face to cover damaged bone and to assist plastic surgery at a later time. (3) The hand to cover open fractures and exposed tendons.

In other situations primary suture is performed provided that the wound has been effectively excised and that it is less than 8 hours old and free from infection.

Contra indications

Suture should not be performed if the closure would bring about tension or in cases with large wounds that have to travel before the stitches are removed.

DELAYED PRIMARY SUTURE

If primary suture is impossible, delayed primary suture should be aimed at, 4–7 days later. This is done in the operating theatre under general anaesthesia. Splints and dressings are removed and the limb prepared as for the primary operation.

Indications

It is safe to close the wound if all swelling and oedema have subsided and there is no active infection. Suture must be carried out without tension and the patient must remain under the surgeon's care.

Contra indications

Infection in the wound. This is present if excision has been incomplete and drainage inadequate. Organisms may have been *introduced from without—by cross infection.*

Further excision must not be attempted. It is right, however, to remove any retained foreign body which is maintaining infection. This should be done through an incision placed over it and away from the wound itself.

Adequate dependent drainage must be established.

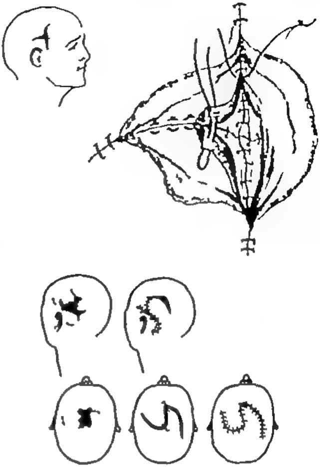
A swab should be taken from the wound to determine the most suitable antibiotic therapy.

SECONDARY SUTURE

This is performed when infection is overcome. Retraction of the skin margins makes closure difficult and it must be decided whether to obtain cover by suture or skin graft. Grafting with split skin, pinch graft, full thickness flaps or pedicles are all possible in peacetime. In war flaps and pedicles should be reserved for base areas.

THE OPERATION

PRIMARY SUTURE



Closure of scalp wounds

1 Scalp wounds should be closed in layers using interrupted sutures. Mattress stitches are preferable where muscles have been divided at right angles to the line of their fibres. If tension would result in the skin suture closure should be achieved by relief incisions or by swinging a flap

Closure of facial wounds

2 When wounds of the face result in the loss of skin covering to cavities lined by mucous membrane the cut edge of the skin should be sewn to the mucous membrane and the patient placed as soon as possible under the care of a maxillo-facial unit.

Suturing should be done without tension, undercutting skin and mucous membrane as required.

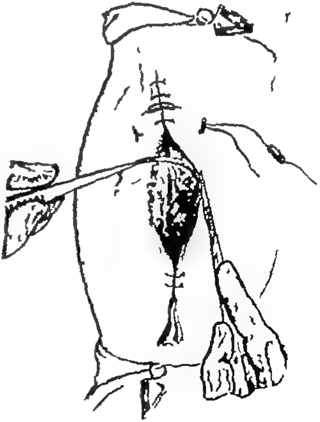
Where watertight suturing cannot be guaranteed (for example when the buccal mucous membrane has been punctured by broken teeth or bone) the wound should be drained.

Closure of wounds of the hand

3 Excision must be complete preserving all viable vital structures and the maximum possible amount of skin.

Severe wounds (machinery accidents and war injuries) are followed by gross oedema. Though primary skin cover is of paramount importance in such cases, where skin has been lost it is wise to cover the excised wound with split skin held in place with dressings and not sutured.

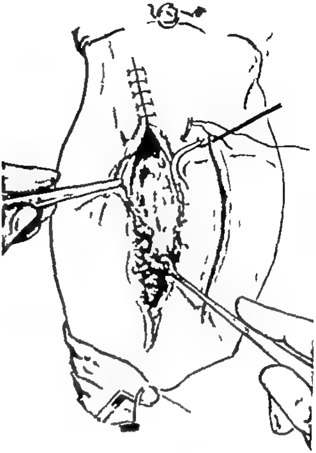
The treatment of major wounds of the hand is a speciality in itself and the patient should be placed in the care of skilled plastic and orthopaedic surgeons as soon as possible.



DELAYED PRIMARY SUTURE

4 Some skin retraction is inevitable and under cutting may be needed. This should be avoided if possible. Great care is needed to avoid damage to young healing tissues and to avoid oozing of blood. Skin edges are freshened with a sharp knife Interrupted sutures, which include the minimum amount of tissue are preferable. A few tension sutures are permissible to avoid tension on the suture line These should take a deep bite of healthy tissue. A drain may be necessary to avoid haematoma formation or the collection of serum

It may be possible to close the wound partially by suture and by covering the rest with split skin.



SECONDARY SUTURE

5 Skin edges are freshened with a sharp knife and undercut to allow approximation Granulation tissue is removed with a spoon until a healthy fibrous base is revealed.
Relief incisions may be needed to assist closure and a small drain may be required as for delayed primary suture

POST-OPERATIVE MANAGEMENT

The post-operative management of the patient and the complications which may arise following surgical intervention are dealt with at the end of the Chapter on Excision of Soft Tissue Wounds (Part II page 9)

[*The illustrations for this Chapter on Primary Delayed Primary and Secondary Suture were drawn by Lt-Col R. S Hunt M B E. F R C S (Ed.) R.A.M C*]

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PRIMARY SUTURE OF SEVERED VESSEL, NERVE AND TENDON

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PRE-OPERATIVE

THE VESSEL

Indications for repair or grafting

Indications for operation are stab wounds (by butcher's knife, carpenter's chisel and similar cuts) clean lacerations (by flying glass) internal wounds (by fractured bone ends) and missile wounds.

The objective indications are to arrest haemorrhage and save life to restore the circulation and save the limb.

Special contra indications

Where vascular circulation is involved the procedure should be withheld if sepsis is present. If other injuries would result in the preservation of a useless limb or if the collateral circulation is adequate for survival and efficient function then the operation should not be performed. Another contra-indication is when the patient cannot remain in the care of the surgeon until the stitches are cut, for example in the case of war wounds.

Pre operative preparation and anaesthesia special equipment

Haemorrhage must be arrested and shock treatment carried out. The affected limb should be elevated. The limb should be cooled by exposure (15 C. is a suitable temperature) for this ice is not generally needed except in hot climates. General anaesthesia is required.

Fine, small instruments should be used with weak springs which do not strain the fingers. Besides the need for arterial clamps of various sizes the surgeon should also make provision for eyeless needles No 5/0 with black silk sutures bulb pressure pipette heparin solution, and papaverine sulphate solution (2·5 per cent)

THE NERVE AND TENDON

In wounds where primary nerve suture is not indicated, and the nerve is identified, two sutures should be passed, through the sheath only to tether the nerve and to help in identification later Tendon suture in the hand is dealt with in another volume

Indications

Primary suture may be performed for clean incised wounds, for example stabs and cuts with sharp implements.

Special contra indications

Suture is contra-indicated in the presence of sepsis and if skin cover cannot be obtained also in war wounds. Positioning for fracture reduction, when present, will produce tension and the repair should be held over

Except in clean incised wounds, the severed nerve and tendon are best treated by delayed suture. For nerves a period of 6 months is safe After this the degree of recovery diminishes. The optimum time is 8 weeks after injury

Pre operative preparation and anaesthesia special equipment

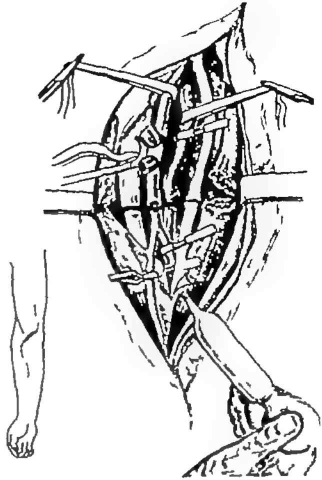
The site of the lesion should be determined and the motor sensory and vascular effects recorded. Further injury must be avoided to a senseless limb and in addition to resting the paralysed muscles they should be protected by splints. General anaesthesia will be required.

The equipment required will be as for the vascular operation less the special solutions but with an electric stimulator in addition.

THE OPERATION

Enlargement of wound

1 A clean stab wound is illustrated involving a severed artery vein, nerve and tendon. Two simple methods of arresting haemorrhage are illustrated—by means of tape and rubber tubing or by bulldog clamps. For large vessels Potts clamps are useful. The wound is enlarged by curved incisions to give complete access to the structures which must be carefully identified and revealed well above and below the site of injury Collateral blood vessels must be carefully preserved. A bulb pressure pipette is a useful irrigator

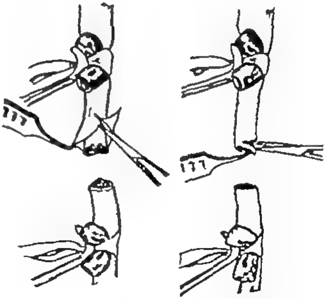


ARTERIAL AND VENOUS SUTURE

Control of bleeding and dissection of adventitia

2 Bleeding from proximal and distal ends is controlled with bulldog clamps or tape clamped over rubber tubing

The adventitia is dissected off the vessel for a short distance from the divided end of the vessel. This is best done with mosquito forceps and fine pointed scissors. The ragged ends of the vessel are trimmed with fine scissors.



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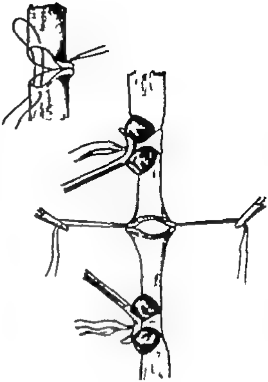
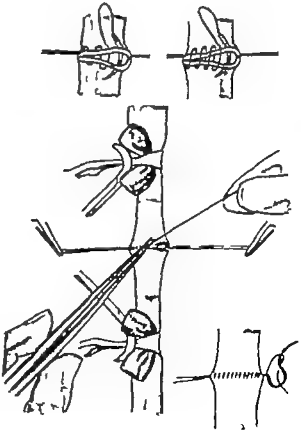


Eversion of vessel ends by stay sutures

3 Stay sutures are placed in the ends of the vessel. These are of the mattress type, passing through all coats and placed diametrically opposite each other When put on the stretch these evert the edges of the vessel. The lumen is irrigated with saline solution to remove clot and debris. A little heparin solution prevents them reforming



Stitching of anterior surface

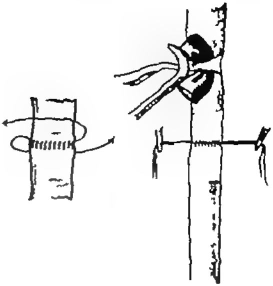
4 The anterior surface is then sutured, using a continuous everting mattress suture or a continuous over and over stitch. This is just as efficient and is quicker to do Each stitch is drawn tight and when the anterior suturing is complete, the thread is tied to the stay suture

Rotation of vessel and suture of posterior aspect

5 The vessel is then rotated to present the posterior surface. The left hand stay suture is passed in front of the vessel and the right hand one behind it. The posterior surface is then closed and when completed the thread is tied to the stay suture.

The suture line is now tested for leaks. This is done by releasing the distal clamps only. Blood *via* the collateral circulation under low pressure fills the vessel and tightens the suture line.

Occasionally destruction of a short length of vessel leaves a gap which can only be bridged by an arterial or venous graft or a plastic prosthesis.



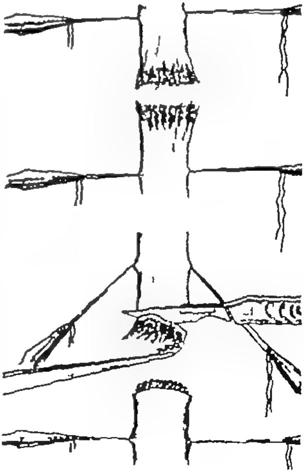
NERVE SUTURE

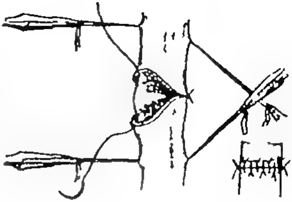
Insertion of stay sutures and trimming of severed edges

6 The nerve is isolated from other structures and the severed ends are placed on a damp swab soaked in saline solution. The nerve is examined to make sure there is no rotation. (Often a small blood vessel on one surface will indicate the corresponding surfaces.) Two orientation sutures of No. 5/0 black silk on an eyeless needle are placed diametrically opposite each other in each end of the nerve. It is useful to identify these by cutting the ends of one side short and leaving the others long.

Only if the nerve ends are ragged will they need trimming. The minimum nerve tissue is removed. A sharp knife causes less crushing but cuticle scissors are easier to use.

Bleeding from the cut ends is controlled by pressure with small swabs.

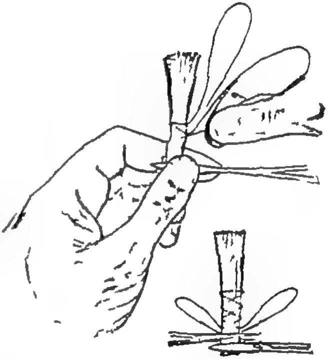




7 **Approximation and joining of ends**

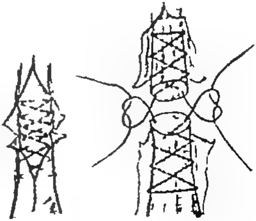
The ends are then approximated by interrupted sutures passing through the nerve sheath only. The repaired nerve is covered with nearby fat or muscle, the wound closed and the limb splinted to prevent tension on the suture line.

TENDON SUTURE



8 **Control and suture of proximal tendon**

Only one simple method is here illustrated. Stainless steel wire, tantalum or braided nylon may be used with an eyeless needle at each end. The frayed ends are grasped with artery forceps. These help to control the tendon and make it easy to grip. Two sutures are used, one for each end of the tendon. Half the suture is passed through the proximal tendon at right angles to the long axis about half an inch from the cut end. One half is again passed through the tendon, this time diagonally, to emerge just below its first point of entry. This diagonal sewing is repeated three times. The frayed end is cut off with scissors.



9 **Approximation of cut ends**

Finally the suture emerges through the cut end of the tendon, near the periphery. The same procedure is repeated with the remaining half suture. The distal tendon is treated in a similar manner till finally four sutures emerge, two from each tendon. Opposing ends are tied and the ends approximated.

If paratendon is present it should be allowed to fall into place, if not the tendon should be buried in fat.

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

THE VESSEL

Sedatives should be administered and the limb elevated and kept cool. A careful watch should be kept on the circulation and if necessary anticoagulants may be given. Pressure must be avoided on the limb and its collaterals

Reactionary and secondary haemorrhage

In the first instance the suture line may give way and will need repair and in secondary haemorrhage if sepsis supervenes the vessel must be tied.

Thrombosis

If an adequate collateral circulation has not developed and thrombus formation occurs, sympathectomy may be advisable, or thrombectomy performed with repeated or increased anticoagulant therapy

Maintenance of blood pressure

Blood loss prior to and during operation is often great and will need replacement. It is essential to maintain an adequate blood pressure and thus ensure a steady and rapid flow over the suture lines. Transfusion should aim at maintaining the blood pressure about half way between 100 mm. of mercury and the normal for the patient's age. A satisfactory daily output of urine is evidence that the blood pressure level is being sustained.

If heparin is used during the operation it is unwise to close the wound completely at once. It should be lightly packed with gauze and left open or at the most a few skin stitches inserted to prevent too much skin retraction not to approximate the skin edges.

A delayed primary suture may be performed in 48–72 hours.

THE NERVE AND TENDON

By splinting the limb tension can be avoided on the suture line in 8–10 days the skin sutures can be removed. Care is needed when removing the splint to avoid moving the limb and stretching the suture line. The limb should remain splinted for 4–6 weeks. Thereafter joints which have been flexed may be gradually extended over a period of 3–4 weeks.

On removal of the splints physiotherapy can be employed to maintain muscle function and treatment given to the skin and pressure points in nerve injuries. By active and passive movements joint movement will be maintained The patient's condition will be considerably improved by encouragement.

Trophic skin lesions

Bed sores should be prevented by efficient nursing

Contracture deformities

Those which cannot be prevented may be treated by the orthopaedic surgeon.

[*The illustrations for this Chapter on Primary Suture of Severed Vessel, Nerve and Tendon were drawn by Lt.-Col. R. S. Hunt M.B.E. F.R.C.S. (Ed.), R.A.M.C.*]

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LOCAL CARE OF BURNS

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EFFECTS OF INJURY

Following any trauma there arises (1) the biological response to injury leading to general effects and (2) the local injury leading to both general and local effects.

To disregard general effects when the local care of burns is discussed would offer an unbalanced and dangerous presentation.

In brief immediately following trauma a neuro-hormonal influence is released. The posterior pituitary liberates an antidiuretic hormone acting on the renal tubules the adrenal cortex releases influences which cause profound metabolic disturbances. The renal tubular changes are maximal in respect to water from the start, but the metabolic changes, although generated from the trauma, are not maximal for some time.

The local effects lead to death or damage of cells and to a disturbance of fluid distribution. The primary fluid shift is from the intravascular channels to the extravascular spaces of the injured area. As a consequence there is local oedema and a decreasing circulating blood volume. Following the primary fluid shift there is a compensatory second shift from the extravascular space to the intravascular channels of the uninjured tissues. The two shifts are attempts by the body to maintain intravascular volume for adequate circulation.

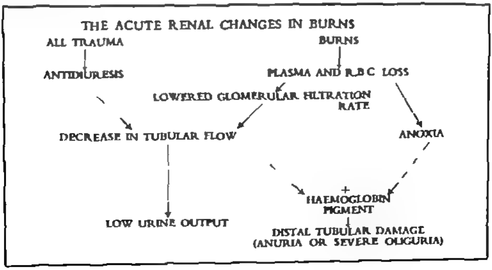
In addition the renal conservation of total body water from posterior pituitary activation is followed in extensive burning by an increased production of metabolic water consequent upon lean tissue and fat catabolism. This might be termed a third component, also of a protective nature the water passing from cells to extravascular spaces.

FLUID BALANCE

On admission of the patient to hospital an immediate estimate of the extent of a burn is essential since the reduction in blood volume is proportional to the extent of the burn the loss is spread over the first 48 hours and is most rapid in the first 8 hours. The reduction in circulating blood volume leads to an early state of anoxia which in turn, leads to damage of liver and kidney cells. In deep burns there is, in addition, an immediate destruction of red blood cells.

In fluid balance therapy the aims are (1) to make up the circulating blood volume with whole blood or plasma as indicated and to keep pace with fluid loss and (2) to give the daily fluid requirements.

A warning must be offered in extensive deep burns to check for the early evidence of haemoglobinuria and associated renal damage.



FIRST-AID TREATMENT

The small superficial burn common from household accidents is simply treated. The immediate pain of this type can be relieved by immersion in cold running water Any blister can be punctured by a sterile needle and the burn covered with a small dry non-medicated sterile dressing which should be kept dry and left undisturbed until healing is accomplished within one week.

In small deep burns and in larger burns the procedures are different. The patients must be got to hospital as soon as possible and any first aid treatment instituted must in no way conflict with later care. Burnt clothing should not be disturbed and any exposed burn should be covered with a clean towel or sheet. For chemical burns any appropriate antidote available should be applied.

In burns of the extremities the early institution of posture to limit oedema formation is advisable. Burns of the hands occurring in mine accidents are best covered with sterile prepared hand absorptive dressings.

In first aid treatment, jellies, creams, wet dressings and local antibiotics should be avoided.

HOSPITAL CARE

The treatment of a superficial burn up to say 5 per cent of the body surface is a relatively simple matter but that of an extensive superficial burn or a deep burn of over 5 per cent of the body surface is a more complex problem Improper care can lead to chronic anaemia, avitaminosis, secondary infection, contractures.

Principles of local care

The local care, undertaken only when the general condition of the patient is considered satisfactory is directed to the affected region as a whole, not merely to the injured skin. Control is desired over the development of oedema, injudicious movement of the part and infection.

Oedema.—Oedema can be limited by posture. Elevation of the extremities is a relatively simple procedure but is often neglected. On occasion, oedema may become so severe as to endanger life or limb This is especially the case in circumferential burns of the neck and extremities. It is possible for oedema to exaggerate the tourniquet effect of an encircling eschar

Emergency tracheotomies may be necessary in burns of the face and neck and release incisions in burns of the hands, forearm, upper arms or legs.

In my opinion it is not possible to limit oedema to any extent by the so-called pressure dressing and such a dressing of itself may lead to complications. Again, I feel it is wrong to cover encircling burns which, by their eschar might lead to dangerous constricting effects. Close observation is essential.

Restraint or splinting.—This is advisable for several reasons. Injured tissues require rest and movement leads to cracks in protective crusts, encouraging infection. Immobilization, especially of hands, should not be continued for any length of time.

Infection.—Infection must be controlled. At one time it was considered that all deep burns become infected but this is incorrect. The incidence of infection in burns, whether superficial or deep is a measure of our surgical organization and techniques.

A burn wound, in classification, should be viewed against the commonly accepted wound types, "open and "closed" A superficial burn at the time of infliction is open" the surface is damaged and the natural protective barriers against infection are reduced. The wound remains "open" until the plasma exudate clots. This natural crust if it remains intact is a perfect cover and completely closes the wound. It separates at the end of 3 weeks and leaves complete skin cover without scarring. Epithelial regeneration takes place from cells lining the hair follicles and to some extent the sweat and sebaceous glands. In local care of superficial burns the aim, therefore, is to attain and maintain the formation of the plasma crust.

A deep burn at the time of infliction is a "closed" wound. The skin surface, although coagulated, has not been broken and if left undisturbed the eschar will remain complete and "closed" for 12-14 days. Around this time the vital skin surrounding the affected area shows evidence of separation from the eschar and moist areas appear

The wound for the first time has become "open" to almost inevitable infection. This is not the time for active surgery. If active surgery is to be adopted it should be before the twelfth day before the burn wound has become open.

To keep a deep burn wound constantly closed the eschar must be excised by the twelfth day and immediately replaced by grafted skin (preferably autogenous). On occasion the optimum time for excision will be soon after *admission on the first day. If a deep burn wound is kept closed and complete grafting has taken place it cannot* become infected. Infection, therefore, becomes a measure of our surgical capabilities. Factors which may prevent this optimum cover sequence are (1) insufficient donor skin (2) inability to remove all necrotic tissue at one operation (3) the extremes of age (4) lack of adequate veins for blood transfusion.

Deep dermal burns from time to time cause problems. Strictly speaking they are "superficial" in type but by the proportion of dead cells the "lag" period in wound healing is prolonged and if low-grade infection arises the remaining epithelial cells are destroyed and the burn corresponds virtually to the deep type. It is, therefore, sometimes advisable to consider deep dermal burns not as superficial types but as deep burns from the first and submit them to early excision and grafting.

COVER SEQUENCE IN BURN WOUND TREATMENT

	SUPERFICIAL BURN	
On admission "open"	In 48 hours "closed" by plasma crust	2–3 weeks normal skin
	DEEP BURN	
On admission "closed" by eschar	In 10–12 days eschar excised "closed" by grafted skin	Seventeenth day healed by grafted skin

Details of local care

Following admission of the patient to hospital the burnt surface is cleansed with saline, blisters are snipped and the surrounding skin is washed with 1 per cent Cetrimide. The burn wound is then placed in an optimal environment to allow the plasma crust to form. It is left exposed to the air of the room or ward (65° F) or absorptive dressings or pads are applied. A dry cool surface deprives organisms of the warm moist environment which they require for proliferation. Overall dryness is essential and patients with circumferential burns even although they are dressed must be routinely turned 4-hourly to allow both surfaces of the dressing to evaporate and dry. There are several erroneous interpretations in respect of the properties of dressings. Dressings by themselves do not close an open wound. Should dressings become damp and the moisture penetrate the covering bandages, all manner of infection passes in. Surface antibiotics give modified protection and carry with them certain dangers. The only safeguard is constant dryness. Dressings which have become soggy *must be removed and fresh dry* dressings applied.

Some parts of the body when burnt are very suitable for exposure, other parts are better to be dressed, while some circumferential burnt surfaces should have one aspect exposed and the other placed on absorptive dressing pads. If an affected part rests on the mattress or pillow it will become and will remain moist. Such a surface must be turned at regular intervals to allow evaporation and dryness.

Exposure

Regions suitable for exposure are the face, the extremities and one aspect of the trunk and genitalia.

Aspects suitable for absorptive dressings are the hands, circumferential burns of trunk and the extremities.

Absorptive dressings

These must be absorbent and their complete outer surface exposed to the air to allow evaporation They consist of a layer of gauze, absorptive cotton wool and a cellulose layer It is an advantage to have shaped dressings. Hand dressings in small bulk can be applied within a few seconds. Sterile rolls, 22 by 86 inches, can be cut quickly to cover an extremity or one half of the trunk. They can be applied direct to the burn surface and held in position with a conforming bandage.

Exposure technique

The burnt area after having been cleansed is exposed to the air of the ward. In nursing care the burnt surface is protected by cages or cradles, while limbs are elevated or suspended to reduce oedema and to limit movement.

Special areas

Face—Following cleansing with gauze swabs rung out of saline the burnt areas are carefully dried and left exposed. The eyelids are lightly smeared with sterile liquid paraffin to prevent splinting by the formation of a too firm crust and also the vestibules of the nose to keep the airways clear

Nursing care is directed towards maintaining an intact dry crust the eyelids and nostrils are mopped frequently

In superficial burns the crust starts to separate in 10–12 days while in well defined deep burns the eschar is excised by the tenth day and grafts are applied.

In the face localized deep burns can be excised soon after the patient s admission to hospital but if the depth is uncertain the crust or eschar is left to separate naturally and grafting carried out where necessary

Eyelids—Careful examination must be made on admission and thereafter daily for damage to the cornea.

Exposure of the cornea may result from contraction of the eschar of a deep burn and necessitate excision of the burnt tissue followed by immediate grafting

Circumferential burns of the trunk—Dryness is again the greatest single factor in care Whether exposure or dressings are employed the patient must be turned four-hourly This is best done with the patient nursed on a special frame bed. Exposure of one aspect can be accomplished while the patient is nursed on expendable absorptive pads. If dressings are favoured it is advisable to keep sterile complete rolls of gamgee in readiness for the emergency These can be cut to shape in a few moments and kept in position by bandages Tulle gras is not necessary Extra padding can be placed over bony points. The importance of turning must be stressed since the dressing on the under surface becomes and will remain moist and, therefore, infected. Routine turning allows evaporation and encourages dryness.

Nutritional care

Although local care only is under discussion, following a severe burn there are profound alterations in the physiological balance of the patient affecting in turn the nutritional state If the diet is inadequate and unbalanced, local healing will be upset. This has, from recent investigation, been shown very clearly

A diet for a seriously burnt patient must contain a balanced mixture of protein, fat, carbohydrate accessory food factors and minerals, as well as an adequate total of calories and water

Nutrition may be maintained through (1) high-protein high-caloric diet, (2) light diet (supplemented) (3) tube-feeding with free diet, (4) tube-feeding alone.

Rehabilitation

Burns can cause disfigurement and they can lead to varying degrees of crippling Disfigurement is commonly related to face and neck and results from alterations in colour scarring, keloid and contractures, or actual destruction of parts. Changes in colour may require active corrective surgery but sometimes conservative cosmetic creams suffice Scarring and contractures may require corrective skin grafts. Destruction of parts requires skilled reconstructive surgery for example noses and ears. Crippling is commonly related to the hands or to the main joints of the extremities. It is also related to eyelids. Crippling caused by skin loss must be relieved by skin grafting

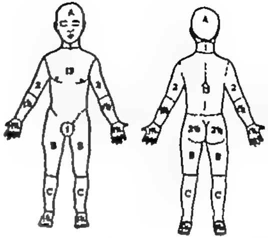
Early physiotherapy for example, massage and wax baths, is very important in the restoration of early movement.

Burn chart (0 7½ years)

1 Method of charting to record the extent and depth of burns in patients up to 7½ years of age.

RELATIVE PERCENTAGES OF AREAS AFFECTED BY GROWTH

Area	0 year	1 year	5 years
A = Half of head	9½	[illegible]	[illegible]
B = Half of one thigh	[illegible]	3¼	4
C = Half of one leg	2½	2½	2¾

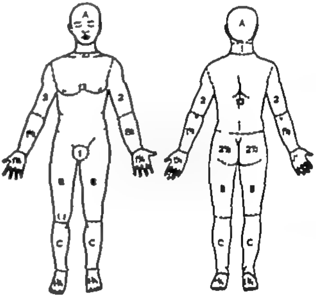


Burn chart (7½ years and over)

2 Method of recording extent and depth of burn in patients over 7½ years.

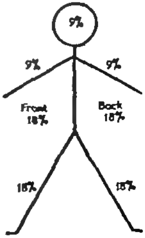
RELATIVE PERCENTAGES OF AREAS AFFECTED BY GROWTH

Area	10 years	15 years	Adult
A = Half of head	5½	4½	[illegible]
B = Half of one thigh	4½	4½	4¾
C = Half of one leg	3	3¼	3½



The rule of nine

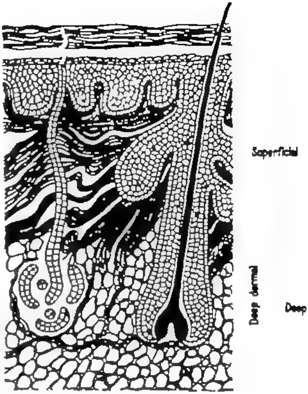
3 A method of recording extent in an emergency An additional 1 per cent can be counted for the neck or genitals. This method is not accurate in children but has proved of value in adults.



Estimation of depth of wound

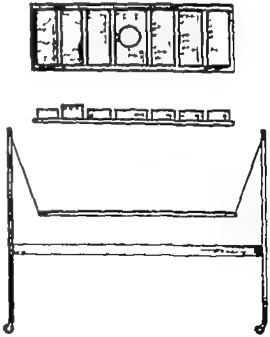
4 The initial burning leads to damage or death of surface skin cells while in some patients there may be damage to the living cells of the upper respiratory passages. Burns in which there has been involvement but not total destruction of epithelial elements are termed "superficial" burns in which the epithelial elements have been destroyed are termed "deep" Some patients exhibit both superficial and deep burns. There is a type termed the deep dermal burn strictly superficial, the amount of viable epithelium remaining is scant.

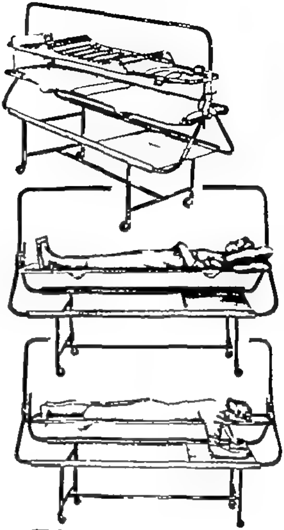
There is no sure way of determining the depth of a burn. Those resulting from moist heat are often superficial, flame burns are commonly deep The pin-prick test is helpful but must not be considered infallible. I find a *colour photograph, taken each day for the first few days,* useful in estimating the possible extent of the deep burn, and the zones, superficial, deep dermal and deep, are clearly defined.



Children's sectional nursing frame

5 This frame is suspended by stout cord from the top and bottom upright standards of the cot. The frame consists of a rectangular metal strip on which a series of aluminium trays are placed. The tray to support the buttock has a convenient piece cut out for nursing On the trays are Dunlopillo slabs covered with mackintosh. The slab under the neck is thicker to obtain hyperextension if required.





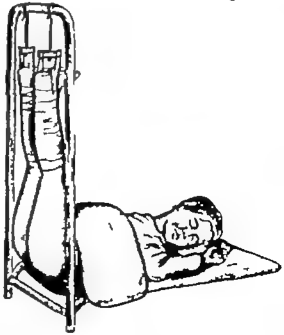
6 The Emesay turning frame

The use of such a frame allows turning of the patient every 3 or 4 hours by a single nurse. Nursing and change of dressing are also simplified while it is possible for the patient to feed himself in any position.

The top diagram shows the two canvases in position ready for turning.

The middle and bottom diagrams illustrate the patient with different aspects exposed.

The frame can be used for the child as well as the adult.



7 Buttocks and perineum

These areas in the adult are best exposed with the patient nursed if necessary prone on a divided mattress with the legs abducted. Dressings are best avoided as they are so easily soiled and then become offensive.

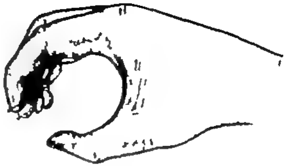
Small children do well with the buttocks slung by extension strips on the thighs to a "gallows" frame.

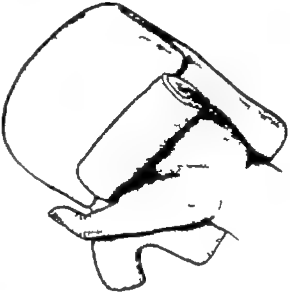
The strips are suspended so that the buttocks are off the canvas.

Urine and faeces when passed are naturally directed away from the burnt areas. Should any part become soiled, it is gently mopped and dried. No harm results.

Hands

8 The limitation of oedema is of first importance and the limb should be elevated at the first opportunity Whatever local procedure is adopted the fingers and thumb must be in the position of function. Although this is taught constantly it is overlooked frequently On admission the hand is carefully examined and the extent and possible depth of the burn are charted. A colour photograph is taken. If there have been circumferential deep burns of the fingers and thumbs, I prefer not to cover the hand for a period of at least 24 hours but to elevate and expose it. This is done to make regular scrutiny of the digits easier If the circulation of the finger tips becomes reduced to possible danger limits, release incisions must be made.



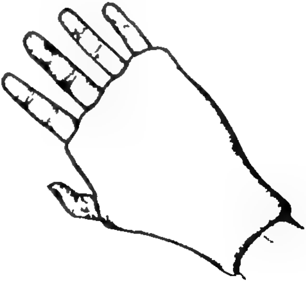


Dressings

9 For dressings I consider that sterile absorptive hand dressings should be prefabricated and kept in readiness then applied with speed. Tulle gras, unless of a dry form, should not be employed as it makes the finger clefts soggy

10 Hand dressings should be undisturbed for 10–12 days. *Following the first dressing* superficial burns will require a further dry dressing until healing is completed while deep burns will require operative excision of the eschar and grafting Localized deep burns of the hands should be excised and grafted following admission. If tendons, bones or joints are exposed some form of flap cover will be necessary

[*The illustrations for this Chapter on Local Care of Burns were drawn by Mr J Wheldon*]



OPEN FRACTURES

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PRE-OPERATIVE

Indications and aims

Infection of the soft tissues and spread of infection to the bony fragments must be prevented. The compound fracture can be converted into a simple fracture—by skin closure, either at once by primary suture, or in 4–7 days by delayed primary suture—and then treated according to accepted methods.

Prevention of infection is accomplished by excisional surgery of the dead and devitalized soft tissues, aided by parenteral penicillin, the bactericidal action of which is on contaminated living tissues. Antibiotics are not a substitute for excision of wounds. They are only valuable ancillaries to competent excisional surgery which must be performed within approximately 8 hours of the injury. After that period the contaminated wound has become an infected wound and the opportunity to convert it into a simple fracture has been lost.

Special contra-indications

A limb in which the main vessels and nerves have been destroyed in association with a compound fracture should be amputated. The problem of a compound fracture with much muscle damage and division of its main artery but with intact nerves is difficult. The upper limb should be saved. In the lower limb, however, 70 per cent of cases of ligation of the popliteal artery and of the femoral artery ultimately require amputation. Therefore at the time of primary operation associated injury to muscle and the amount of bone loss often decide the issue.

Pre-operative preparation

General

Parenteral penicillin, 500 000 units, should be given twice daily; antitetanus serum, 1,500 units, should also be given. After covering the wound with a sterile dressing the fracture is immobilized with first aid splintage whilst shock is being treated. There should be minimal movement of the patient—indeed, it may be necessary to take the patient to the theatre in his bed or litter rather than move him from bed to trolley to operating table.

In treating the shock, there may be more blood lost than is apparent. A loss of 8 pints of blood is a reduction of the circulating blood volume to 70 per cent. This is a critical level. The cold tachycardia pattern of shock needs at least 2 pints of blood as a prophylactic before operation. The cold hypotensive pattern has a blood loss to below the critical level and needs urgent and rapid transfusion which should be continued throughout the operation. On the other hand the vaso-vagal pattern only needs simple rest for an hour or so.

The fracture should be examined radiographically in two planes, and any opaque foreign bodies noted.

Preparation of the limb

After the initial dressing is removed the wound is covered with flavine-soaked gauze while a wide area of skin surrounding the wound is cleansed thoroughly with a detergent. This area of skin is shaved by movements away from the wound margins and the surrounding area is again cleansed with a detergent. Sterile stockinet is rolled over the foot or the hand and up the limb to the distal level, while a sterile towel is applied around the extremity at the proximal level of the prepared operation field. A tourniquet is not used.

Anaesthesia

General anaesthesia is required. In the shocked patient induction with Pentothal has its dangers.

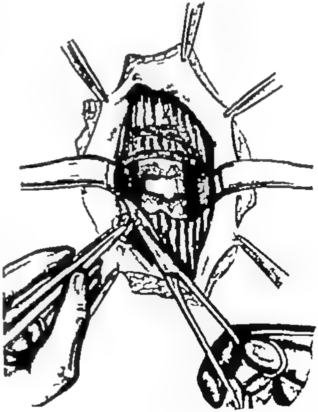
THE OPERATION

Excision of the wound

The skin

1 Skin is very valuable and wide excision should be avoided. Certainly pulped and hopelessly dead skin should be removed and this may be sufficient. At the most $\frac{1}{8}$-inch of the remaining skin margin may be removed.

The wound is now enlarged by incising the skin in the long axis of the wound both proximally and distally. These incisions should be adequate to permit exploration of all parts of the wound. Contaminated subcutaneous fat and the shredded margins of the deep fascia are liberally excised. These devitalized structures have a poor blood supply and a poor resistance to contamination. The deep fascia is now incised in the direction of the skin incision. This vital step in excisional surgery opens up the wound and deep pockets to permit excision and cleansing of the wound depths. Transverse incisions of the deep fascia at the ends of the fascial incision may be an added help. The now widely opened deep fascia allows the wound to be decompressed and drained after the cleansing has been completed.

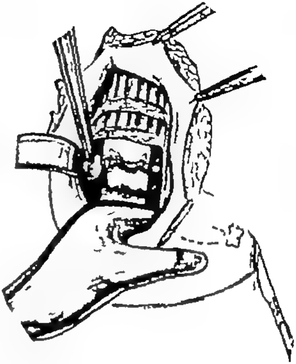


The muscle

2 Methodically working from superficial to deep layers, all dead, crushed, damaged and devitalized muscle is excised with curved blunt pointed scissors back to healthy muscle. In general wide areas of muscle can be excised in the limbs without reducing the limb function appreciably. Muscle which does not bleed, does *not contract* when pinched and has changed colour is damaged and is the breeding ground for the organisms of gas gangrene. Wound cleansing is completed by removing blood clot, foreign material and debris. Gentle irrigation of the wound with saline solution assists by washing out clot and debris and by floating up muscle and fascial planes.

Removal of foreign bodies

3 Remove all foreign bodies from the walls and the depths of the wound (clothing, dirt, missiles). The track along which these have passed will be lined with devitalized muscle which is excised. Finger exploration in the wound is helpful here to identify foreign bodies. Do not make a prolonged search beyond the confines of the wound and thus open up healthy tissue spaces. Instead deep recesses may be approached by counter incisions through fascial planes rather than by cutting through muscle.



Bone fragments

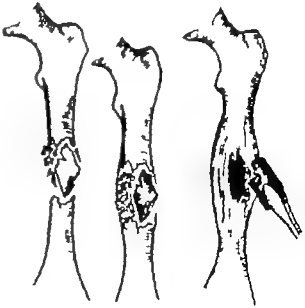
4 Retain all bone fragments whether small or large, whether loose or still retaining soft tissue attachments.

(1) Cancellous bone will act as a scaffolding *for callus and will aid in early bone union.*

(2) If large whole-thickness fragments are removed a gap will be left which may require a bone graft later. If such a fragment is grossly contaminated it should be removed, cleansed, plunged into boiling water and replaced in alignment in the fracture site.

(3) In the absence of infection this fragment will become revascularized and will act as the graft. If infection does supervene it will act as a strut to prevent collapse of the periosteal tube while a solid involucrum is being formed.

(4) It can be removed perhaps a year later by which time union of the fracture will have occurred.

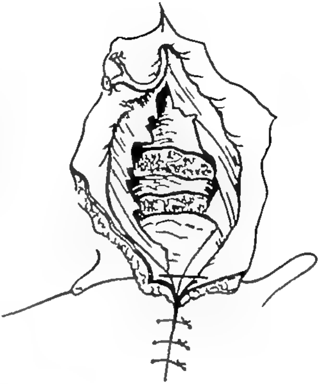


Closure of the wound by primary or delayed primary suture

Haemostasis

5 To a large extent this is obtained by pressure with warm wet packs or by applying artery forceps to each bleeding point and twisting them at the end of the operation Ligature material should be used sparingly Only large vessels need ligation with thread or fine catgut. No attempt is made to repair the deep fascia or to bring the muscles together Instead, the depths of the wound are left open to allow the tissues to swell post-operatively without any tension (decompression of the wound)

The decision has now to be made to close the skin at once by primary suture or to delay the wound closure and repair the skin with delayed primary suture.

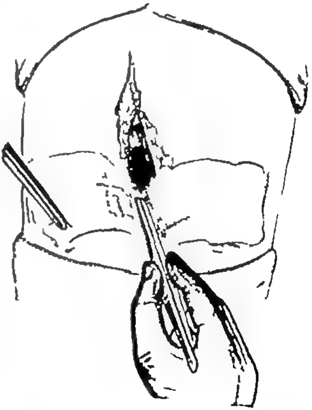


Primary suture of the skin

It should be realized that it is never imperative to close the skin at once. Only clean incised wounds in whose depths there is little or no crushed or destroyed muscle should be closed and then only if the skin edges will come together with interrupted sutures without any tension. Never insert drains into compound fractures where skin has been closed by primary suture. Fractures that compound from within out can be closed but if there is any doubt whether the wound will heal by primary intention then these too should be closed by delayed wound closure. If pr mary suture has been performed then the patient must be retained in that hospital until the sutures are removed (10–14 days) and the skin union is firm.

Delayed wound closure

6 All other compound fractures should be left open for drainage by laying a few strips of plain gauze lightly between the walls of the wound. That portion of the gauze in the wound depth is always loosely placed to avoid the effect of plugging Encircling adhesive tape or bandage to hold the wool and gauze in position is avoided so as to lessen the constrictive effect on a limb about to swell. The limb is splinted and this fracture with its open wound can be transferred to another hospital. Whether it is transferred or not the skin should be closed with interrupted sutures 4–7 days later when the post-operative oedema has subsided.



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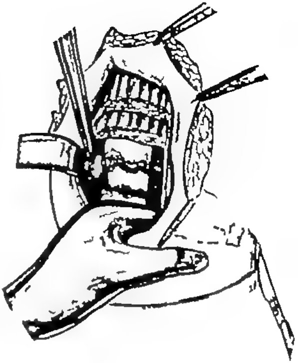

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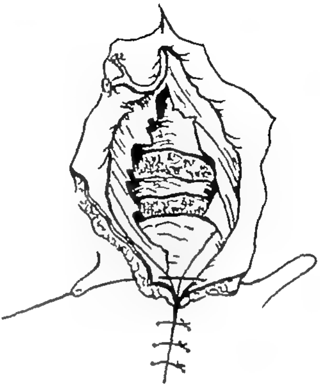

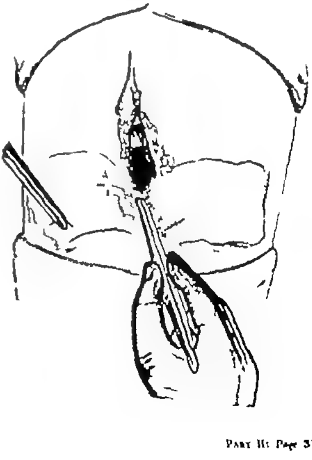

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Elevation and splintage

At operation the fracture is reduced and immobilized in splintage suitable to individual fractures, and in the ward the limb is elevated. If plaster of Paris is used it should be well padded to allow for swelling of the limb. A watch must be kept for interference with the distal circulation. If this is threatened the plaster must be split or bivalved.

Care of the wound

Parenteral penicillin should be continued for 7–10 days. In large wounds with much muscle damage the penicillin administration is persisted with for 21 days. If primary skin closure has been obtained the sutures are removed in about 10 days. These patients should not be moved from hospital to hospital until the sutures have been removed and the suture line healed.

If skin closure has been delayed, the wound is inspected in the theatre between the third and fifth day It may be necessary to remove the splintage. If the wound is clean it is closed. Occasionally there is a local area of cellulitis about the wound in an otherwise well patient and closure is again delayed and splintage re-applied with elevation for a few days until this is overcome. Wound culture and sensitivity tests at this stage may indicate an antibiotic other than penicillin.

Wound closure

The methods of wound closure are either by delayed primary suture or in those cases where there is actual skin loss by skin graft. Split skin either in sheets or as postage stamps or whole thickness skin by means of a rotational flap or even a pedicle flap may be used.

Bare bone must be covered with skin split skin will take on periosteum and although it only gives a thin unstable scar it will have served its purpose in preventing infection. It can be excised later and replaced with whole thickness skin. However bone devoid of periosteum cannot be covered with split skin and a full thickness skin flap is required. When skin cover has been obtained the definitive treatment of the now simple fracture commences.

Infected fractures

If infection is established at the fracture site dead soft tissues are removed and the infected areas are drained by free incisions in the long axis of the limb which are left wide open. The infected soft tissues and the bony fragments are immobilized in plaster of Paris after the method of Winnett Orr to allow the wound to granulate from the bottom up This avoids the danger of secondary infection by repeated wound dressings. Early sequestrectomy is advisable but a large whole thickness fragment of bone must be retained to prevent the collapse of the periosteal tube until the rigid involucrum is formed.

[*The illustrations for this Chapter on Open Fractures were drawn by Lt-Col R. S Hunt M.B.E., F.R.C.S (Ed.) R.A.M.C.*]

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OPEN INJURIES TO JOINTS

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PRE-OPERATIVE

Indications

In open injuries to joints treatment should be carried out to prevent suppurative arthritis with its hazards to life and limb and to achieve the maximum restoration of function.

This ideal has been achieved as the result of experience gained of war wounds of joints. Because of its exposed position, the knee joint is very vulnerable and is the site usually quoted. During the early part of World War I a conservative attitude was adopted with a high death rate and an amputation rate of about 70 per cent (Frankau). During 1916 excisional surgery of wounds was becoming standardised and an amputation rate of 25 per cent was achieved which fell by 1917 to 7 per cent. Experience in the Spanish Civil War (1936–37) showed that joints were resistant to infection provided they were properly cleansed of dead and devitalised tissues and foreign bodies and were then closed off from surrounding tissues.

Further, this joint cleansing and closure could be carried out up to 24 hours after injury. Buxton reported 278 knees so treated during the Middle East campaign (1940–41) and had an amputation rate of 4·4 per cent, a death rate of 1·0 per cent and a suppuration rate of 34·8 per cent.

The advent of penicillin completely changed the picture. With the same surgery but aided by parenteral penicillin and locally instilled penicillin into the knee joint, Burns, Young and Muller (1945) reported a series of 101 wounds of this joint with no deaths, no amputations and 75 normal knees, and 21 Army Group reported that 32 wounds of the knee joint required, after surgery, between 2 and 5 aspirations and penicillin injections into the joint at 48-hour intervals to prevent joint infection. Early healing of the wound without joint infection allowed rehabilitation to be started earlier and very often a full or useful range of painless movement to be regained. Should, however, joint surfaces have been extensively damaged, arthrodesis or arthroplasty could be safely carried out at a later date.

Pre operative preparation

The wound is covered with a sterile dressing. Shock is treated, antitetanus serum or if appropriate tetanus toxoid is given and penicillin, half a million units twice a day, is administered parenterally.

Position of the patient

The skin is prepared as for wounds of bone. Towels should be draped circumferentially to allow easy access to any aspect of the joint. Where possible a tourniquet is used and the limb so placed that it can be manipulated during operation to obtain full view of the interior of the joint. Thus in the knee joint the leg is dependent with the knee flexed at 90 degrees. Good lighting is necessary.

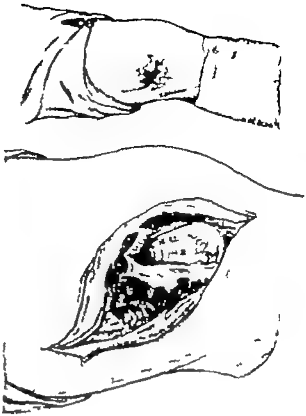
THE OPERATION

Arthrotomy

1 Arthrotomy through an incision large enough to provide satisfactory exposure to the intra-articular damage is essential.

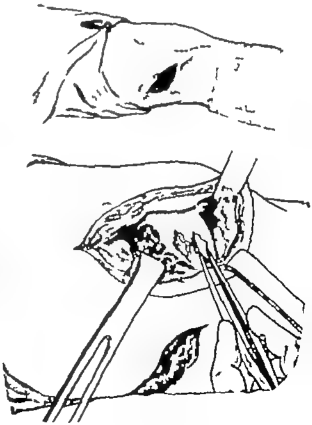
Via the wound

This is obtained by excising then enlarging the wound of entry. Only hopelessly destroyed skin is excised. The skin wound is then enlarged in order to get at the wound depths. Devitalized tags of deep fascia are excised and then the deep fascia is incised in the direction of the skin incision. This allows the wound depths to be opened up with retractors so that destroyed muscle and blood clot can be removed. It is rarely necessary to excise the capsule or the synovial membrane. The whole wound is then enlarged to obtain the maximum exposure of the joints.



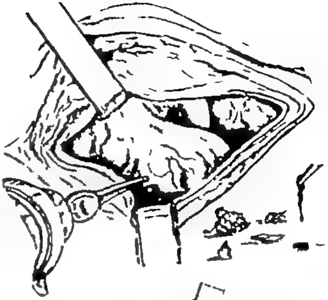
Via standard incision

2 In this method the traumatic wound is excised and for the moment is left open. It may be that enlargement of this wound would endanger vital structures or alternatively if enlarged, it would give inadequate exposure to the intra-articular damage. Therefore the joint is opened through a standard arthrotomy incision with fresh instruments, for example a median para-patellar incision for the knee joint



Joint cleansing and joint flushing

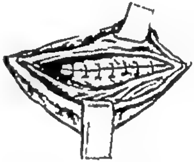
3 All foreign bodies and material all loose bone fragments, devitalized fragmented or loose articular cartilage, damaged menisci and blood clot are removed. Foreign bodies embedded in bone seen in the operative field are removed. Those remote from the field are best left to be removed later as a secondary procedure. All clot between bone fragments is removed. In the knee if the patella is grossly comminuted it is best excised. The joint is gently but thoroughly irrigated with sterile saline solution or water to remove any hidden debris.



Joint closure

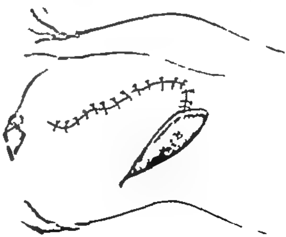
By suture of capsule or synovial membrane or both

4 This is obligatory In both the arthrotomy incision and the traumatic wound the capsule or the synovial membrane (whichever is the easier) is closed with the minimum of interrupted plain catgut sutures.



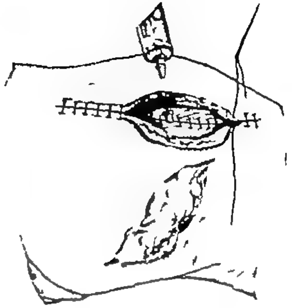
By whole thickness skin

5 Rarely where a joint cannot be closed by the previous method it must be closed with full thickness skin either by advancement or rotation flaps or rarely by pedicle grafts. Exposed articular cartilage will not survive and failure to cover it will result in necrosis and suppurative arthritis. Joint closures can be performed up to 24 hours after wounding



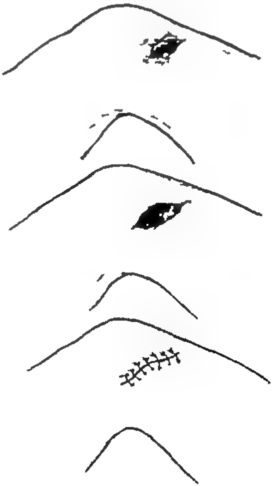
Aspiration and penicillin instillation

6 The skin and soft tissues superficial to the capsule in the traumatic wound should be left open to be closed by delayed primary suture 3–5 days later. The standard arthrotomy *incision should be closed in layers at once.* When the surgical procedure is completed the joint is aspirated with a wide-bore needle and 100 000 units of penicillin dissolved in 5–10 ml. of sterile water are instilled directly into the *joint cavity.*



Indications to close the wound by primary suture

7 There are many penetrating wounds of joints, particularly of the knee joint, the result of industrial and traffic accidents, which do not suffer intra-articular damage and which have *little muscle damage.* If the injury is up to [illegible] hours old and the joint has been dealt with as described the synovial membranes, the capsule and the excised wound may be closed by primary suture. These patients should be retained in the same hospital with elevation and immobilization of the joint until skin union is firm.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Immobilization and elevation of the joint

Associated fractures if present have been manipulated and moulded into satisfactory position at operation and this reduction is maintained by splintage suitable to each joint. In the knee a Thomas splint with fixed skin traction such as a Tobruk splint or a single hip spica, is suitable. When plaster of Paris is used, a hinged window is cut out over the joint to allow inspection and post-operative aspiration and penicillin instillation. This lid is re-applied to prevent window oedema Elevation of the limb and immobilization of the injured joint in its position of physiological rest are essential whether a fracture be present or not. Parenteral penicillin is continued until the danger of infection of the soft tissues outside the joint has passed.

Post operative aspiration and penicillin instillation into the joint

Excess synovial fluid, particularly if blood-stained, is a good culture medium and must be aspirated until an adequate circulation in the synovial membrane is restored when in the absence of infection, synovial fluid will not accumulate Because penicillin in sufficient concentration to be bactericidal does not pass from the blood stream into the synovial cavity it should be instilled directly into the joint after each aspiration. A wide-bore needle is used and from 50 000 to 100 000 units of penicillin, dissolved in 5–10 ml. of sterile water are instilled, the amount varying with the clarity of the synovial fluid. If mildly purulent fluid is aspirated the larger quantity of penicillin is used. In these cases culture and sensitivity tests may show that streptomycin is indicated instead of penicillin. Usually 3–5 aspirations and instillations at 48-hour intervals are required to prevent or overcome infection within the joints.

Delayed closure of the soft tissues about the joint

If the skin has not been repaired by primary suture it is closed in the operating theatre by delayed primary suture 3–5 days after injury Plastic methods are occasionally needed for closure

Rehabilitation

If no infection has occurred in the joint, active movement and assisted movements of the affected joint can be commenced when the soft tissues have soundly healed. If, however there has been infection which has been overcome, active exercise of the joint is delayed for 3–6 weeks although during this time static contractions of the muscles about the joint can be started. Active exercises of the joint are then gently begun but the joint is watched for any renewal of infection

Suppurative arthritis

If frankly purulent synovial fluid is aspirated from an ill patient established suppurative arthritis is present. Adequate drainage of the joint by liberal incisions which are left widely open must be established and the limb is immobilized to put the joint at rest and allow ankylosis to occur in the optimum position for that joint. Deep-seated joints such as the shoulder and the hip cause much anxiety and it may be necessary to excise the head of the humerus or of the femur to allow free drainage. Superficial joints respond well to open drainage and immobilization. In the knee joint it may be necessary to remove the patella and to nurse the patient on his face

Established pyarthrosis may result in the gravest toxaemia and while amputation may be hazardous it must be considered before it is too late

[*The illustrations for this Chapter on Open Injuries to Joints were drawn by Lt.-Col R. S Hunt M.B.E. F.R.C.S (Ed.) R.A.M.C.*]

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USE OF SKELETAL TRACTION IN FRACTURES

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PRE-OPERATIVE

Indications

Skeletal traction provides the surgeon in fracture work with an efficient traction force transmitted directly to bone and on which he may pull with a controlled force. In addition it has the advantage that while in use joints may be exercised and joint stiffness avoided, muscle tone is retained, and any wound present is ready for inspection and treatment.

Special equipment

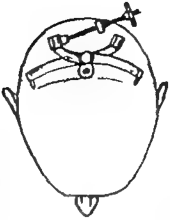
Skeletal traction can be obtained by calipers, Kirschner wire, or a Steinmann pin

Calipers have sharp points which secure a firm hold by penetrating cortical bone. They can only be applied to bony prominences, for example the femoral condyles or the malleoli. Types in use are the Pearson ice tongs, the Bohler large for the femoral condyles and small for the malleoli or calcaneus, and the Crutchfield tongs for skull traction. While this last is frequently used in its particular field, the other forms of caliper have largely gone out of fashion.

Kirschner wire is a highly tempered steel wire of a gauge 0·75–3 millimetres diameter It is supported by a telescopic guide as it is drilled through the bone. When the wire is rendered taut in the Kirschner stirrup they become one fixed unit and any rotary movement of the stirrup causes movement of the wire in bone, leading to infection of bone from the point where the wire penetrates the skin. If too large a traction force is used the wire may cut through the bone. For these reasons the Steinmann pin is preferred in many centres. This is a rigid steel pin from 4 to 6 millimetres in diameter and either 5 or 6 inches long A Bohler stirrup (large or small) which fits over the pin is designed to allow the stirrup to pivot freely on the nail even if the direction of the traction force changes through a considerable angle. It is immobile in bone, and will remain so in the cortical bone for 2–3 months with little danger of pin track infection. The pin may be gently hammered through bone or attached to a handle and driven through by steady pressure and a twisting movement of the wrist. If the pin is vigorously hammered through bone the cortical bone is liable to split. If the pin is attached to a power drill, and drilled at high speed, the friction between the rapidly rotating pin and bone generates sufficient heat to destroy a ring of bone and devitalize adjacent tissues. Injured tissues are prone to infection and ring sequestra may form. After the pin or wire has been placed in position the portion next to the skin *is dealt with as in illustration No 9 When the stirrup has* been fitted the sharp ends of the Steinmann pin are covered with corks. If a Kirschner wire is used the ends are removed with wire cutters.

Pre-operative preparation and anaesthesia

The skin is shaved, cleansed with a detergent, dried and painted with iodine. The area is towelled off as for any operation on bone and the surgeon is masked, wears a sterile gown and gloves. A general anaesthetic is preferred to local anaesthesia except for the application of Crutchfield tongs. After the pin or wire is inserted, a general anaesthetic permits manipulation of the fragments and reduction of the fracture. Subsequently the skeletal traction merely maintains the reduction



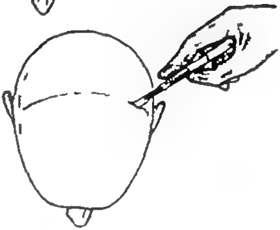
THE OPERATION

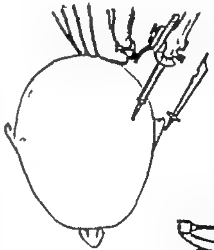
Application of Crutchfield tongs

Landmarks and skin incision

1 Crutchfield tongs when used in fracture dislocations and dislocation of the cervical spine are applied transversely to the vertex of the skull in a vertical plane which passes through the articulations of the cervical spine. The tips of the mastoid processes are approximately in the plane. The operation can be performed in bed.

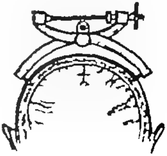
After the skull has been shaved and the skin prepared, a line joining the mastoid tips is marked out with a dye on the vertex. With the traction bar resting on the mid point of this line the tong parts are lowered to the scalp and the points of contact are marked to indicate the proposed stab wounds. These areas are injected with procaine and the scalp incised down to bone with incisions just long enough to admit the points.





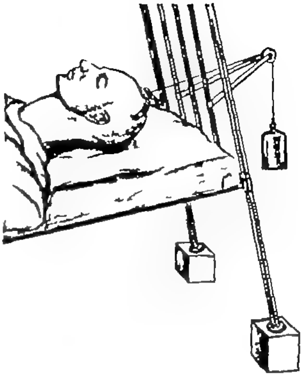
Drilling the skull

2 The outer table of the skull is drilled with a special drill 2 mm. in diameter to a depth of 8 mm. in children and 4 mm. in adults to reach the diploe only. This drill has a guard 3 or 4 mm. from the point to prevent excessive penetration. The tong points are fitted into the bony perforations and are secured by adjusting the thumb screw which locks the tongs so that the points will not bore into the skull. The junctions of the scalp incisions and the tongs are sealed off with wool soaked in Mastisol or Tinctura Benzoini Composita (B.P.C.)



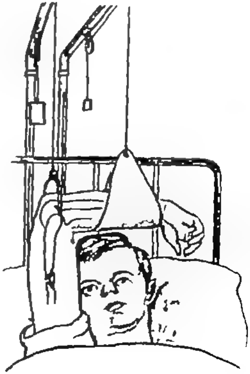
Position of the patient during traction

3 With the patient horizontal, traction is so arranged that the neck is extended or hyper extended. The head of the bed is blocked and a traction force of from 5 to 45 pounds can be used. In dislocations and fracture dislocations traction is begun with 15–20 pounds with the neck extended. It is carefully controlled by x-ray every 15–30 minutes. The traction force is slowly increased until there is radiographic evidence that the articular processes are disengaged. At this point the cross bar carrying the pulley is lowered so that the neck is further extended or hyperextended and only when there is radiographic evidence of accurate reduction is the weight reduced to a few pounds. Skull traction with this weight is continued for 2–3 weeks and is then replaced by plaster immobilisation with the neck in extension for a further 6 weeks. If the articular facets are fractured the reduction may be so unstable that continuous skull traction may be required for 6 weeks or more. In these it may be necessary to re-apply the tongs at a different site (*see* post-operative care)



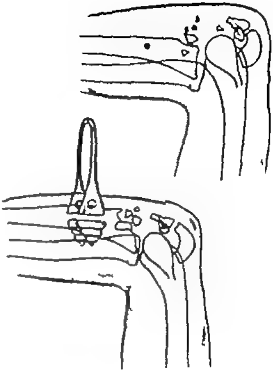
Skeletal traction via the olecranon

4 Skeletal traction is not often required for fractures of the upper limb. If it is used for the arm a Steinmann pin or a Kirschner wire is passed from the medial to the lateral side through the olecranon posterior to the ulnar nerve. The smaller diameter Kirschner wire may be preferred particularly as it will not be retained for a long period. The position of the patient during traction is shown. Only rarely is skeletal traction required for fractures of the humerus and if used at all the dangers of distraction of the fragments must be remembered.



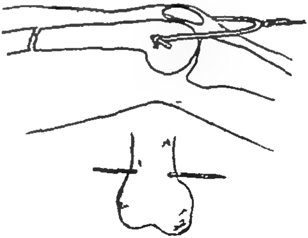
Skeletal traction via the shaft of the ulna

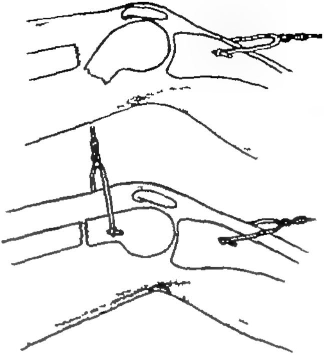
5 Although its use in fractures of the forearm is rare, there is one fracture-dislocation of the radius and ulna at the elbow joint where, *with the patient positioned* as above and with a Kirschner wire passed through the shaft of the ulna close to the fracture site, reduction of the dislocation is readily achieved with a weight of 6–7 pounds. Active use of the elbow joint is commenced immediately. The reduction will remain stable at 3 weeks so that the wire can be removed and the patient becomes ambulant with a collar and cuff at the wrist, the elbow being at a right angle. Active use of the elbow is continued. Although reduction of the comminuted fracture of the olecranon is inadequate the fragments readily unite with fibrous tissue to leave an elbow joint with a functional result of full flexion, extension, pronation and supination but without a powerful range of extension without resistance.



Supracondylar traction in fractures of the femur

6 A Steinmann pin can be passed through the expanding shaft just proximal to the femoral condyles. When this site is used there is liability to stiffness of the knee due to seepage from the pintrack around the capsule of the knee joint. Skeletal traction *via* the tibial tubercle is preferred.





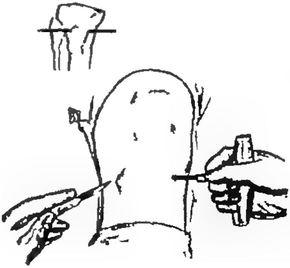
Skeletal traction through the femoral shaft

7 In supracondylar fractures of the femoral shaft two traction forces can be used—one in the tibial tuberosity in line with the femoral shaft and the second close to the fracture site in the shaft of the smaller distal femoral fragment with overhead traction to correct the backward displacement of this fragment. When the Steinmann pin is inserted into the distal femoral fragment the knee should be flexed. This avoids pressure necrosis of the skin on the pin

Insertion of a Steinmann pin through the tibial tuberosity

8 First thread the limb through the ring of a Thomas splint and then support the calf muscles with a sling while the nail is being inserted in order to avoid tension of the skin at the nail sites. *The pin is inserted at the level* of the prominence of the tibial tubercle and three-quarters of an inch posterior to it. The angle of insertion is 90° to the long axis of the femur and parallel to the floor when the leg is extended to 165 or 170 degrees. Since the object of the traction is to restore alignment to the femoral fragments, it is a mistake to insert it at right angles to the long axis of the tibia.

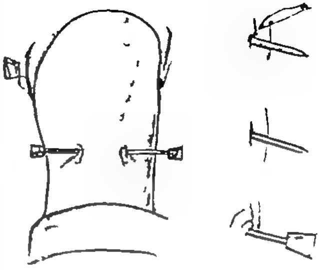
The skin is incised and the nail driven through by manual pressure and wrist rotation using a handle attached to the nail. As the point emerges on the opposite side, the skin is incised and the nail pushed on so that an equal amount projects on either side.



Details to avoid pintract infection

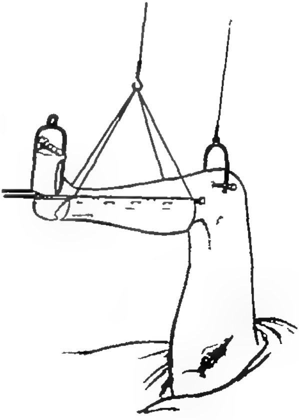
9 Occasionally the skin puckers at one side of the nail. A small incision here will equalize the skin tension around the nail and avoid pressure necrosis of the skin against the nail. The junction of the skin and the nail is sealed off with wool or gauze soaked in Tinctura Benzoini Composita (B.P.C.) or Mastisol. Collodion does not bond with metal as either of these solutions do.

A large size Bohler stirrup is threaded over the nail whose ends are then enclosed by cork. After the fracture has been reduced and the splintage suspended from a frame, reduction is maintained by weight traction applied from the stirrup.



Skeletal traction in buttock wounds

10 A Steinmann pin in the tibial tuberosity with a weight attached to a Bohler stirrup and with the lower limb suspended in the 90-90-90 degree position allows for easy nursing of wounds of the upper thigh and buttock whether a femoral fracture is present or not. This position should not be maintained for more than 3 or 4 weeks because of the liability to knee stiffness.



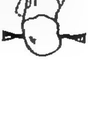
Skeletal traction through the shaft of the tibia

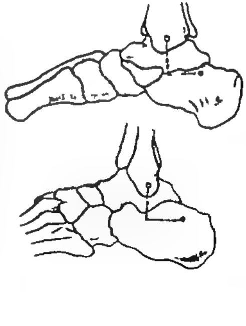
11 The site of election is 1½ inches above the ankle joint in the expanding lower end of the shaft. Above this point the tibia is so dense that there is difficulty in pushing the nail through the bone and if a hammer is used the shaft may split.

Tibial shaft traction is satisfactory for fractures of the tibia and fibula in their upper halves but when used for fractures below this level the distal tibial fragment will angulate forward with distraction at the fracture site. To overcome this traction *via* the os calcis is preferred so that the line of force is in the direction of the calf muscles. When these are elongated overriding of the tibial fragments will be corrected without angulation.

Skeletal traction via the os calcis

12 The point is inserted 1 inch distal and dorsal to the lateral malleolus. If this measurement is taken from the medial malleolus there is a real danger of entering the subtaloid joint. The danger of calcaneal traction is involvement of the substragaloid joint either by direct penetration by the pin (or wire) or by infection of this joint from pintract infection. Both may lead to stiffness with permanent painful limitation of inversion and eversion of that joint. If continuous traction is required for the lower limb then tibial tubercle traction or traction through the lower tibia, 1½ inches above the ankle joint, should be used.





13

Technique for inserting a Steinmann pin into the os calcis

The foot is drawn over the edge of the operating table and is held at right angles to the tibia. A stab incision is made over the proposed point of insertion. The pin is held parallel to the floor and at right angles to the tibia and pushed through the os calcis by hand with a rotary movement of the handle. The detail of managing the pin and skin junction to prevent pintract infection is described above

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Skull traction

When the Crutchfield tongs are used for either closed reduction or as a preliminary to open reduction of dislocations and fracture dislocation of the cervical spine they must be inspected frequently and perhaps tightened daily They cannot be used in the same place for more than 8 weeks as the prongs become loose in the skull and may pull out.

Distraction in fractures of the limbs

The danger of skeletal traction, particularly if continuous traction is used, is delayed union of the fracture. If distraction persists and immobilization of the fragments is incomplete delayed union may progress to non-union. Distraction is especially dangerous in the first 2–3 weeks when there is a tearing apart of cellular layers and strangulation by tension of the growing capillaries in the organizing fracture haematoma. Further if distraction is allowed to persist there is such a loss of muscle tone that when the traction force is removed the gap will persist. Transverse fractures of the femoral shaft and fractures of the tibial and fibular shafts are most vulnerable. It should be noted that excessive traction may correct angulation of the bony fragments but it will also produce distraction

Repeated radiographic control of the fracture is necessary and any distraction is immediately corrected.

[*The illustrations for this Chapter on Use of Skeletal Traction in Fractures were drawn by Lt.-Col R. S Hunt M.B.E., F.R.C.S (Ed.) R.A M C.*]

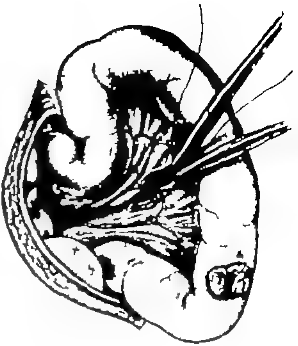
Bibliography

Crutchfield, W G. (1933). "Skeletal Skull Traction." *Sth. Surg.*, 2, 156.
— (1938). *J Bone Jt Surg* 20, 696.
Watson-Jones, R. (19.5). *Fractures and Joint Injuries.* Edinburgh Livingstone.

Assessment of visceral injuries and control of active bleeding

3 A rapid but systematic examination of all the organs which may have been injured is made. The nature of this diagnostic exploration is varied according to the type of incision used, the conditions found (including the apparent sources of bleeding, free intestinal content, free bile, faecal smell, etc.) and a judgment of the track of the missile.

If active bleeding is occurring it must be controlled at once, but with care not to occlude any collateral vessels.



Foreign bodies, peritoneal toilet and closure of incision

If there is a retained foreign body it should be sought for with the fingers and removed only if readily accessible. Peritoneal contamination with bowel content should be removed as fully as possible by suction and swabbing.

Separate visceral injuries may be dealt with in any convenient order but the construction of a colostomy for injuries of the colon or rectum should be left to the last.

At the conclusion of the operation the laparotomy incision is closed according to the surgeon's usual technique for potentially infected incisions. A drain is inserted to the muscle layers.

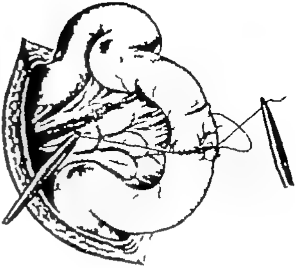
SMALL INTESTINE

Examination of the small intestine

4 Examination of the entire length of the small intestine is always advisable and should be completed before a decision to resect any portion is made; while the remainder of the gut is being examined any severely damaged section is retained outside the abdomen under a warm moist pack. Individual lesions suitable for repair may be dealt with as they are encountered in the course of the examination.

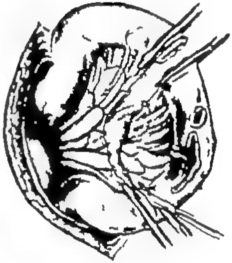
Closure of individual tears or perforations

5 A single area of damage to the wall of the small intestine and multiple injuries if not too large or too close together are treated by closure in the transverse axis of the bowel to ensure that the resulting stenosis is minimal. If some part of the circumference of the bowel remains intact, stenosis is not likely to cause subsequent trouble. Excision of the edges of the tear is not necessary unless there are evidently non-viable portions. The repair is usually made with two layers of sutures but if there is need to save time, one layer of invaginating sutures may be used.



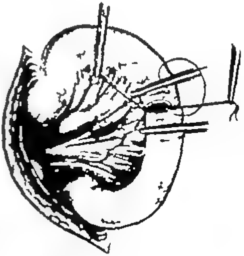
Resection of severely damaged small intestine

6 Resection of a length of intestine is required if one large tear or multiple injuries within a limited length of intestine are such that repair would take longer or would result in a more serious obstacle to peristalsis than an end-to-end anastomosis, or if an extensive injury of the mesentery or an unusually severe injury of the intestine itself has devitalized a segment of the gut.



Anastomosis by open end-to end suture

7 Peritoneal contamination by intestinal content has already occurred and there is no need to use aseptic techniques in anastomosis, but light occlusion clamps may be applied a short distance from the cut ends to prevent further escape of contents. Anastomosis is usually made by the end-to-end technique using two layers of sutures. The opening in the mesentery is closed with care not to injure mesenteric vessels.



STOMACH AND DUODENUM

Repair of a wound of stomach

8 The lesser sac should be opened to permit examination of the posterior wall of the stomach (and the pancreas) Gastric wounds are repaired with two (or three) layers of sutures. In the body of the stomach the axis of repair may be longitudinal but if the injury is near the cardia or the pylorus care is taken not to stenose these openings.

Exposure and repair of injury of anterior wall of duodenum

9 Rupture of the relatively fixed portions of the duodenum must be suspected in non-penetrating abdominal injuries.

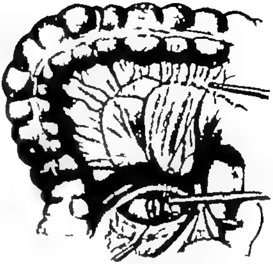
The vertical part of the duodenum is exposed by division of the right part of the gastrocolic omentum and of the peritoneum above the proximal part of the transverse colon. The transverse colon is then mobilized downwards by blunt dissection. A rupture or wound of the anterior wall of the duodenum is repaired with two layers of sutures in the transverse axis of the gut.

Exposure and repair of injury on the posterior wall of duodenum

10 The posterior aspect of the flexures and vertical part of the duodenum is inspected by dividing the peritoneal reflection on the right (lateral) side and turning the duodenum with *the head of the pancreas medially* An injury on the posterior aspect of the duodenum is repaired in the transverse axis with care not to injure the ducts at the ampulla of Vater

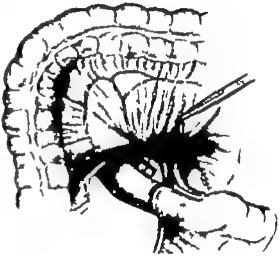
Exposure and repair of a wound of the third part of the duodenum

11 The third part of the duodenum is inspected by lifting the transverse colon and mesocolon upwards. If there is evidence of injury the third part of the duodenum may be exposed by dividing the peritoneum at the root of the mesocolon on the right of the middle colic vessels.



Management of severe injury at the duodeno jejunal flexure

12 Rarely (more particularly by a closed injury) the duodeno-jejunal flexure is ruptured. If possible the gut is repaired in the transverse axis. If the injury is more severe and resection is required, it may be necessary to complete the division of the bowel at the site of injury and to bring the proximal end out to the right of the superior mesenteric vessels. Continuity is re-established by end-to-end anastomosis in this position.



LIVER, GALL-BLADDER AND PANCREAS

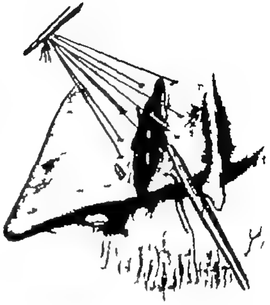
LIVER INJURIES

The temporary control of severe bleeding from an injured liver

13 If bleeding from an injury of the liver is profuse it is promptly controlled by gripping the vessels in the free edge of the lesser omentum between finger and thumb (Pringle's method)

Control of bleeding from a wound of the liver simple suture

14 Lacerations of liver tissue have usually stopped bleeding by the time they are exposed at operation. If so they are best left alone except that portions of liver which are evidently devitalized should be excised. If active bleeding *is still taking place, it may be controlled by* deep catgut sutures. The passage of a sharp needle through liver substance is likely to add to the bleeding and is to be avoided. Sutures should be inserted with a special blunt needle or with a large round-bodied needle reversed so that the threaded blunt end tears rather than cuts the liver substance.

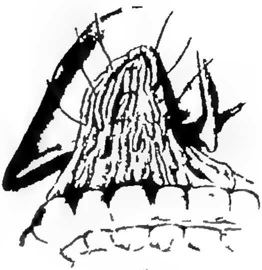


The use of fibrin foam or oxidized cellulose in a sutured wound of liver

15 Haemostasis in a deep liver wound may be encouraged by placing fibrin foam or a roll of oxidized cellulose in the wound and closing it by suture over the thrombogenic material. The illustration also shows the use of multiple mattress sutures which may be placed in tiers at varying depths.

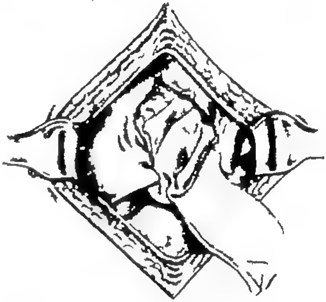
Technique of suturing friable edges of a tear in liver

16 Deep catgut sutures may be inserted parallel to the edge of the tear in the liver and about 2 cm. from it. The deep coating sutures enclose these thus reducing the tendency to tear the liver substance. The deep parallel sutures also help to control bleeding



Packing a liver wound with omentum

17 A large and bleeding tear of the liver may sometimes with advantage be packed with part of the greater omentum which is retained in position by a few deep sutures passing through liver substance and omentum



Packing a liver wound with gauze

18 As a last resort, a large and bleeding liver wound may be packed with a gauze roll. The end of the gauze pack is brought out through the abdominal wall and the pack is removed gently on the fourth or fifth day

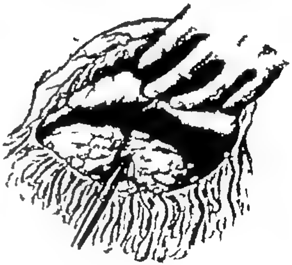
Drainage

19 In all but the most minor liver wounds, a drain is inserted to the region to ensure the escape of blood from subsequent bleeding and more particularly of any bile that may leak from damaged bile ducts.

GALL-BLADDER INJURIES

Injury of gall bladder repair and cholecystostomy

20 A severely damaged gall-bladder should be removed by the usual technique for cholecystectomy If the wound is less extensive, it is repaired and drainage of the gall-bladder established by a tube which is enclosed at the fundus of the gall-bladder by a purse-string suture and brought out through the incision or by a separate stab incision in the abdominal wall at an appropriately close point.



PANCREATIC INJURIES

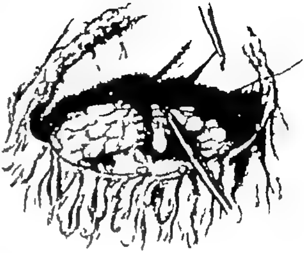
Injury of pancreas repair and drainage

21 An injured pancreas is exposed through the gastro-colic omentum. The damaged pancreatic tissue is repaired as far as is practicable by interrupted sutures of non-absorbable thread. It is important to close by ligation both ends of any divided pancreatic duct if this can be identified. The area is drained.

22

Transection of pancreas closure of divided ends

If the injury is so severe as to transect (or nearly so) the body or tail of the pancreas, the divided ends may be oversewn with interrupted sutures of non-absorbable thread, taking care in each case to obliterate the main pancreatic duct either by ligation or mattress suture Alternatively the tail of the pancreas may be removed with the spleen and the other divided end closed. (See Part III, Section VI.) The area is drained.



Injuries of the bile ducts

See Part III, Section VII.

Injury of the spleen

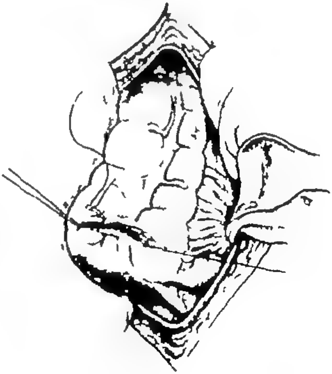
See Part III, Section V

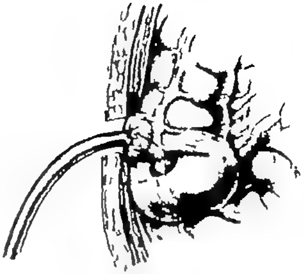
LARGE INTESTINE AND RECTUM

23

Repair of wounds of the caecum or proximal ascending colon

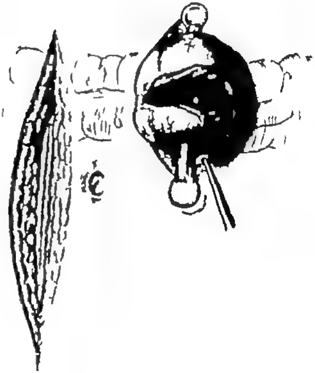
A wound of the caecum or proximal ascending colon is best treated by repair and invagination in the transverse axis, followed by caecostomy If the caecal wound is situated on the anterior surface the opening in the bowel may be used to construct the caecostomy





Construction of caecostomy for wounds of the caecum or proximal ascending colon

24 The caecostomy tube should be brought through a separate small incision in the right iliac region (*See* Part III Section IX.)



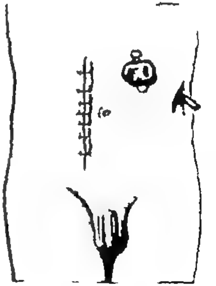
Exteriorization of damaged colon

25 A wound of any part of the large intestine between the proximal ascending colon and the distal pelvic colon is best treated by the formation of a colostomy which exteriorizes all the damaged bowel preferably through a separate incision of appropriate position and length. A spur may be made but is inadvisable if its construction involves technical difficulties or creates more dead space The exteriorized loop is retained by a glass rod or length of rubber tube and is left open. (*See* Part III, Section IX.)

Search for retroperitoneal lesions of colon

26 If the nature of the wound, the inferred track of the missile or signs of retroperitoneal echymosis suggest that there may be a lesion on a retroperitoneal aspect of a sessile part of the colon this part must be mobilized for *thorough inspection.*

Mobilization of ascending or descending colon is obtained by incision of the peritoneal reflection on the lateral side followed by blunt dissection with the fingers till the bowel can be rotated inwards with its blood vessels. If an injury is found, it is exteriorized as above.



Drainage of retroperitoneal area if contaminated

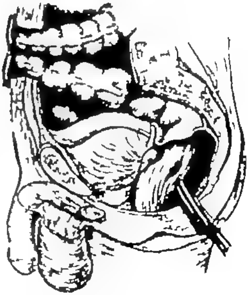
27 When a retroperitoneal area has been involved by the wound or by the operative procedure and is likely to be infected, it is drained. This is usually best done by a drain through a separate small incision in the flank on the appropriate side.

Proximal colostomy for wounds of distal pelvic colon or rectum

28 If the rectum or a portion of the pelvic colon too near the pelvi-rectal junction to be exteriorized is injured, a proximal (pelvic) colostomy is made. The injury is repaired if accessible, but if it is in the rectum below the peritoneal reflection, repair is not practicable. The colostomy should be opened immediately.

Drainage in cases of extraperitoneal wound of rectum

29 If there is reason to believe that the rectal wound has involved contamination of the pelvic cellular tissues, as when the rectal wound is extraperitoneal, a drain is inserted alongside the coccyx or after removal of the coccyx.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Gastric aspiration is continued until diminishing quantities indicate that the stomach is emptying through the pylorus. Intravenous infusions of appropriate electrolyte solutions are required until oral intake can be re-established. A "wide spectrum" antibiotic should be given from the time of operation.

If a drain has been inserted, it is removed after 4–6 days. If a colostomy has been made it is closed after 3–6 weeks, when the patient's general condition is satisfactory. Before closure of the colostomy the distal bowel should be washed through to ensure that inspissated faecal masses have been cleared.

Shock and haemorrhage

In spite of careful haemostasis during operation there may be some continued blood loss afterwards as from a wound of the liver; even in the absence of bleeding the wound and the operation are usually sufficient to cause further depletion of blood volume. The patient's general condition and particularly the blood pressure, should be watched carefully and further transfusion of blood given as required.

Peritonitis and paralytic ileus

When any part of the bowel has been involved, a more or less severe peritonitis will occur. The treatment is based on adequate chemotherapy and management of the associated paralytic ileus by gastric suction and intravenous infusions of fluid and electrolytes.

Pulmonary complications

Chest complications are most likely to occur after thoraco-abdominal wounds when there may be indications for aspiration of haemothorax, drainage of empyema or of lung abscess. Partial collapse of the lung may be due to plugging of a bronchus by inspissated secretions; breathing and coughing exercises are valuable in prophylaxis and treatment of early cases but if the collapse does not resolve quickly or is very large bronchial aspiration by catheter or preferably by bronchoscopy should be employed.

Residual abscess

An abscess may form at any time within several weeks of the wound and operation. It is most commonly pelvic or subphrenic and is treated by drainage. (*See* Part III, Section IV.)

Dehiscence of laparotomy wound

"Burst abdomen" may be the result of multiple factors, including infection of the wound, severe abdominal distension and poor nutrition of the patient before the injury occurred. Treatment is by resuture with multiple through-and-through sutures and attention to causative factors.

Other complications

Other early complications which may have to be dealt with include faecal or biliary fistula, prolapse or retraction of a colostomy and gas gangrene of the abdominal wall. Late complications are incisional hernia, intestinal obstruction due to adhesions, pseudo-pancreatic cyst and rarely a malabsorption syndrome if very large portions of small intestine have been resected.

[*The illustrations for this Chapter on Abdominal Injuries were drawn by Mr. D. P. Hammersley.*]

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INJURIES TO THE KIDNEY

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The kidney may be injured by external violence or a penetrating missile In civilian life renal trauma is commonly the result of a heavy blow or crush injury to the loin and is unaccompanied by an external wound (closed injuries) Gunshot injuries or stabbings account for most penetrating wounds (open injuries)

OPEN WOUNDS OF THE KIDNEY

Open wounds of the kidney are usually the result of gunshot or stabbing injuries. In such circumstances the renal lesion may be only an incident amongst more serious abdominal or chest injuries, which demand precedence in treatment. There is much evidence that uncomplicated projectile injuries of the kidney heal well and that a conservative policy regarding the removal of the injured organ is justified. Gross renal lesions, however require primary nephrectomy and it is wise to perform this operation when there is doubt regarding the viability of the kidney or the likelihood of further severe haemorrhage. When a wound of the kidney is associated with a laceration of the colon nephrectomy is usually a prudent procedure so as to avoid the possibility of leakage of urine into a retro-peritoneal space already contaminated by faeces.

CLOSED INJURIES OF THE KIDNEY

The renal lesions vary from mild contusions to gross lacerations of the renal parenchyma, which may involve the calices and pelvis. The renal vessels may be partially or completely torn rarely the ureter is divided.

Initial treatment and investigations

The majority of renal injuries resolve without operative interference Unless there is evidence of a concomitant abdominal injury a watching policy should be pursued and observation directed to determining the severity and persistence of the haematuria and perirenal bleeding The patient is rested in bed and pain relieved by sedatives. The pulse and blood pressure are recorded regularly The degree of haematuria at each act of micturition is noted. Unfortunately in the early stages it is not possible to determine with accuracy the severity of the lesion and to forecast the ultimate course The following investigations should therefore be made lest operative treatment may become necessary

Intravenous pyelography will indicate if a sound kidney is present on the non-injured side. Absence of a pelvic or *caliceal outline on the injured side does not necessarily indicate a severe lesion for secretion may be temporarily* inhibited by even a mild degree of trauma.

Full blood count haemoglobin estimation and determination of blood group should be carried out.

When the history of trauma is definite, cystoscopy and retrograde pyelography are rarely required to establish the diagnosis. Retrograde pyelography undoubtedly assists the assessment of renal damage but carries with it the risks of increasing renal bleeding and introducing infection With reasonable care and the use of suitable contrast media no serious harm should result. Even so as a general rule, such examinations are probably best avoided. If however the history of trauma is rather indefinite and the injury apparently insufficient to account for the haematuria, or if the history suggests possible injury to an already pathological kidney then cystoscopy and retrograde pyelography are fully justified.

Indications for operative treatment

Exploration of the damaged kidney is indicated when haematuria or perirenal bleeding persists and threatens to endanger the patient when the perirenal haematoma is large and unlikely to resolve completely when the haematuria is due to trauma to a grossly diseased kidney and in the presence of uncontrollable renal or perirenal infection which may be giving rise to recurrent haematuria.

EXPLORATION OF THE INJURED KIDNEY

Anaesthesia

General anaesthesia with an endotracheal tube in position is desirable. An intravenous saline drip is set up so that the patient may be rapidly transfused in the event of severe haemorrhage developing during the operation.

Approach to the kidney

The kidney is best approached through a loin incision with a sub-periosteal resection of the twelfth rib (twelfth rib incision) Gross haematoma formation may be found on incising the transversalis aponeurosis and bed of the twelfth rib or the bleeding may be confined within the perirenal fascia or capsule. If still intact the perirenal fascia is incised. Blood and clot are gently removed by suction and mopping and the kidney sought. If there is any suspicion of an intra-peritoneal lesion the abdominal cavity may be explored by opening the peritoneum in the lower portion of the wound.

The suspicion of accompanying intra-peritoneal injuries may occasionally call for a laparotomy Trans-abdominal exploration of an injured kidney may be difficult and when laparotomy reveals a gross unilateral perirenal haematoma it may be advisable to close the abdomen and explore the kidney through the loin

Assessment of the renal damage

The kidney is gently mobilized. Lacerations of the cortex are noted and their severity assessed. The renal pelvis and vessels are next examined. Occasionally the renal vessels are completely torn across and the kidney either lies free in the perirenal fat or remains attached by its ureter In such circumstances the proximal ends of the vessels retract and may be lost in a mass of blood-stained fat and connective tissue It is desirable to find and tie off the vessels. They may however be extremely difficult to identify and if bleeding has ceased it is unwise to pursue too prolonged a search lest uncontrollable bleeding be started in the haematomatous tissues. When a persistent ooze is present and the severed vessels cannot be found a haemostatic dressing such as Oxycel or gelatin sponge is applied to the bleeding site and the renal bed packed with a roll of six inch gauze.

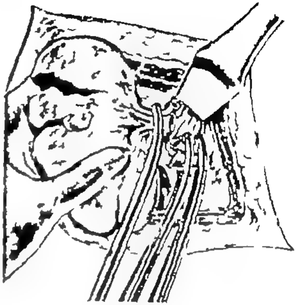
Choice of operative procedure

The aim of the surgeon is to preserve a maximum of functioning renal tissue Whenever possible bleeding is controlled and the renal lacerations repaired. If however conservative treatment has already been tried and failed then the renal injuries are usually found to be so severe that attempts at repair may possibly hazard the patient s life and only result in the retention of an almost functionless organ. Under such circumstances and provided the contralateral kidney is healthy a nephrectomy should be performed. When the damaged kidney is the sole organ or the remaining kidney functions badly repair must be attempted by suturing lacerations with plain or ribbon catgut or by removing the damaged area by partial nephrectomy

THE OPERATIONS

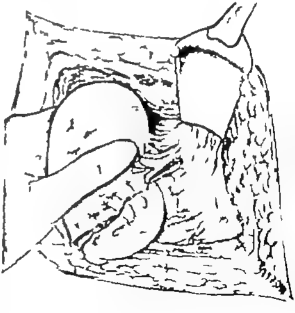
Nephrectomy

1 When the decision has been made to remove the kidney the ureter is first divided between clamps and the distal end ligated. The kidney and ureter are then gently raised to expose the renal pedicle. This area may be heavily infiltrated with blood rendering identification of individual vessels difficult. It is well to perform the minimum of manipulation and dissection lest in so doing a damaged vessel is inadvertently torn. Such a vessel may retract and be difficult to retrieve. Division of the pedicle by the three clamp method is the safest procedure. The pedicle is tied off with 2 ligatures of No. 2 chromic catgut. Any remaining bleeding points are ligated. When the control of bleeding is complete no drainage is required. If slight venous oozing persists or if there has been gross haematoma formation, the renal bed is drained with a soft rubber tube for 24 hours.



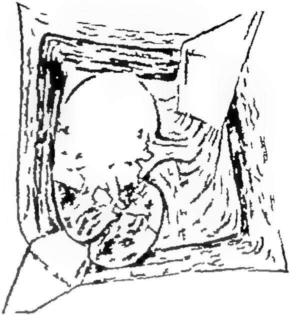
Suture of lacerations of the renal parenchyma

2 To repair a ruptured kidney it is essential to control bleeding and suture the lacerations. An attempt is made to pick up bleeding vessels in the parenchyma and to ligate them with 4/0 plain catgut. The contused renal tissue may render this an impossible task and it may be necessary to try to underrun such vessels. When a pelvic or calyceal tear is recognized in the depth of the laceration it is desirable to close it with fine plain catgut sutures but frequently such measures are impossible. To help to control bleeding a piece of crushed muscle may be placed in the laceration. The margins of the parenchyma are then drawn together with No. 2 plain catgut mattress sutures. To prevent these sutures cutting out they should whenever possible include the renal capsule. As the renal pelvis or calices may have been perforated it is essential to drain the renal bed for a few days.



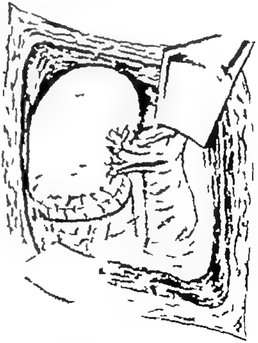
Repair of renal lacerations with ribbon catgut

3 Catgut mattress sutures may tear out and fail to hold the walls of a renal laceration in firm contact. To avoid this difficulty ribbon catgut may be used. Small parallel incisions about 1 cm. apart are made in the renal capsule at the appropriate sites and the capsule between them is raised from the kidney surface. The catgut ribbon is then laced round the kidney and tied just tightly enough to bring the lacerated walls into good apposition. Several bands of ribbon catgut may be used. The margins of the laceration between the bands may be sutured with No 2 plain catgut stitches.



Partial nephrectomy

4 If the trauma is confined to one pole of a kidney a partial nephrectomy may be performed. The vessels running to the injured area are picked up and divided at the hilum. The damaged tissue is then removed by a wedge excision. Bleeding points are ligated or underrun and closure of openings into the calices or pelvis is attempted. Redundant capsule is turned over the margins of the wedge excision which are then brought together with No 2 plain catgut mattress sutures. A few supplementary sutures may be necessary.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Following operation any blood loss should be restored by transfusion. To control or prevent infection the appropriate antibiotics or sulphonamides are administered. After nephrectomy a drain may be removed in 24 hours if the renal pelvis or calices have been opened the drainage tube is shortened on the second day and removed as soon as any urinary or sanguinous discharge ceases—usually on the third or fourth day When a gauze pack has been used to control haemorrhage removal is deferred to the fifth to seventh day

During convalescence the urine must be kept under constant review Urinary antiseptics are administered until the urine remains permanently sterile.

At the end of 8 months the function of the injured kidney is assessed by intravenous pyelography

Paralytic ileus

Retro-peritoneal haematomas are frequently accompanied by some degree of paralytic ileus. If this condition becomes troublesome fluids by mouth are stopped, gastro-duodenal suction is instituted and fluid and electrolyte loss are restored by an intravenous drip

Secondary haemorrhage and sepsis

Following the repair of an injured kidney some haematuria may persist for a few days and slight perirenal bleeding may occur It the bleeding persists or recurs the presence of renal sepsis must be suspected. Improved control of infection has lessened this complication, but occasionally a secondary nephrectomy is necessary Rarely infection of a perirenal haematoma gives rise to a perirenal abscess, which requires drainage.

Urinary fistula

When a severe renal laceration involving the pelvis or calices has been repaired a urinary fistula may persist for a short time. Unless there has been gross injury to the renal pelvis or ureter it rarely remains permanent.

[*The illustrations for this Chapter on Injuries to the Kidney were drawn by Miss J Perry*]

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INJURIES TO THE URETER

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TRAUMATIC INJURIES

Owing to its small size and deep position within the body the ureter is very rarely damaged by non-penetrating injuries. Gunshot and stabbing wounds of the ureter are commonly accompanied by serious lesions to other organs and the late occurrence of a urinary fistula may be the first evidence of such damage. In civil life injuries to the ureter are usually the result of surgical procedures.

SURGICAL INJURIES OF THE URETER

Pelvic operations.—The ureter is most commonly damaged during difficult operations on the uterus or its appendages. It may, however, be divided or tied during excision of the rectum, in the course of removing a vesical diverticulum or during any operation which involves dissection of the pelvic floor. A segment of the ureter may be deliberately removed in carrying out a partial cystectomy or during the removal of a pelvic tumour.

Vaginal operations.—One or both ureters may be injured or tied during vaginal operations on the cervix or uterus, in performing an extensive colporrhaphy or closing vesico-vaginal fistulae.

Cystoscopic investigation.—The ureter may occasionally be perforated by a ureteric catheter. Even though the catheter may have entered the peritoneal cavity uneventful healing usually follows withdrawal of the instrument and treatment with suitable antibiotic drugs. The ureter may also be damaged by the use of semi-flexible ureteric stone extractors, which may either perforate the ureter or injure its wall during withdrawal of the calculus. Immediate surgical intervention is rarely required but occasionally extravasation may necessitate exploration and drainage of the retro-peritoneal tissues.

The time of recognition of the injury

The injury may be noticed at the time of operation or may reveal itself at a later date by the onset of one or more of the following conditions: (1) anuria, (2) peritonitis or pelvic cellulitis, (3) renal pain, (4) leakage of urine from an abdominal or vaginal wound.

The aim of treatment

The aim of treatment must be to conserve the function of the kidney corresponding to the damaged ureter. Enthusiasm for such a policy must not, however, be allowed to jeopardize the patient's life.

TREATMENT OF INJURIES RECOGNIZED AT OPERATION

The ureter may be damaged by being caught in a ligature or haemostatic forceps, or may be partially or totally divided.

Ligation of the ureter.—If the ligature has been loosely tied there may be little or no visible damage to the ureteral wall and uneventful recovery may occur. When there is any doubt of the degree of damage a small linear incision may be made into the ureter a short distance above the damaged area and a bougie passed down the ureter. This will demonstrate the patency of the ureter and allow more detailed inspection of the wall. If the wall has been severely crushed late stricture formation is almost inevitable and the damaged area should be excised.

Ureter crushed by a haemostatic clamp.—A closed haemostatic clamp causes gross damage to the ureteral wall and fistula or late stricture formation will occur. The damaged area should therefore be excised.

Partial section of the ureter.—The ureteric opening is closed with a row of 8/0 plain catgut sutures. The area of the injury is drained by a soft rubber tube placed extra-peritoneally.

Complete division of the ureter.—When the ureter is completely divided the function of the corresponding kidney may be retained by anastomosis of the divided ends of the ureter (uretero-ureterostomy), re-implantation of the proximal end of the ureter into the bladder (uretero-cystostomy), re-implantation of the ureter into a tube flap from the bladder, or substitution of a segment of ileum for the lower end of the ureter. Other methods are implantation of the proximal end of the ureter into the sigmoid colon, and also the formation of a ureterostomy.

The choice of time and method of repair

Temporary ligation of ureter

It is desirable to carry out the reparative operation at the time of the injury. If the repair is to be both immediately successful and also not impaired at a later date by stricture formation it must be performed in a meticulous manner. Careful closure of the peritoneum over the anastomosis is usually necessary and drainage of the extraperitoneal tissues must be arranged. These procedures may take a considerable time, and in a patient already shocked by a severe operation may endanger life. In such circumstances, provided abdominal palpation has demonstrated the presence of a second kidney, it is justifiable to tie off the divided ends of the ureter with thread ligatures and to delay reparative procedures to a second operation. This procedure avoids any immediate trouble and provided two firm ligatures are placed on the proximal end of the ureter neither immediate nor late leakage of urine will occur. Resumption of normal renal function will occur if the repair is carried out within one month and has been recorded after as long as three months.

General technique

Re-implantation into the bladder

Re-implantation of the proximal end of the ureter into the bladder probably gives the most certain results but can only be performed when the division is low down and sufficient ureter is available. The scope of this method has been extended by the use of a tube flap from the bladder or an isolated loop of ileum to re-form the lower end of the ureter, but such measures are rarely suitable for emergency repairs.

When implanting a ureter into the bladder it is essential to avoid stenosis at the site of anastomosis. It is also desirable that the ureter should be inserted as close as possible to its normal point of entry and that by running an oblique course through the bladder wall a valve-like mechanism should be maintained to prevent reflux up the ureter. In practice the site of implantation is dependent on the amount of ureter available and must be chosen so that the anastomosis is made without tension.

The operation is usually carried out through an extraperitoneal approach to the bladder. When the ureter has been cut in the course of a pelvic operation it has been re-implanted directly into the peritoneal surface of the bladder; more commonly the implantation is made into a bare area of bladder wall and the peritoneum then closed over the anastomosis.

End-to-end anastomosis

When the division is some distance from the bladder anastomosis of the divided ends may be performed. This operation has earned a reputation for giving rise to stricture formation. Fibrosis at the line of union inevitably causes some diminution in the calibre of a ureteral anastomosis. If the anastomosis is made oblique and if fibrosis is reduced to a minimum by careful suturing of the ureteric margins, the resulting stenosis need not diminish the calibre of the original ureter. Suturing the margins in eversion may also lessen the tendency to stenosis (Davalos, 1947).

Implantation into the large bowel

Implantation of a ureter into the caecum is inadvisable owing to the dangers of hyperchloraemic acidosis. A ureter may be implanted into the sigmoid colon. The passage of urine from the rectum as well as from the bladder, however, is a great burden and when two sound kidneys are present most patients would prefer the removal of the kidney corresponding to the transplanted ureter. Ureterostomy is to be avoided except under very exceptional circumstances.

TREATMENT OF INJURIES RECOGNIZED AFTER OPERATION

Injury to the ureter may be indicated in the post-operative period by the onset of anuria, the development of peritonitis or pelvic cellulitis, the formation of a urinary fistula or the presence of loin pain.

Anuria

Anuria following a pelvic or vaginal operation suggests that either both ureters or the ureter from a single functioning kidney have been injured. When the anuria is unaccompanied by symptoms of peritonitis or pelvic cellulitis it is probable that the ureters have been ligated or caught in sutures. If the absence of urine is confirmed by catheterization, cystoscopy is performed and catheters passed up the ureters to determine if obstruction is present.

When obstructive anuria follows a severe pelvic operation re-opening the abdomen offers little hope of giving immediate relief and effecting satisfactory ureteric repairs. A nephrostomy carried out on one side will relieve the anuria and tide the patient over until fit for a secondary reparative operation. Provided the repair is not delayed beyond a week or two there is no need to perform bilateral nephrostomy

If obstructive anuria follows a vaginal operation the wound must be opened and any deep stitches removed. Provided cystoscopy and ureteric catheterization then shows patency of the ureters no further treatment is indicated. If the ureteric catheters cannot be passed a unilateral nephrostomy must be established.

Anuria accompanied by peritonitis or pelvic cellulitis indicates the probable leakage of urine into the peritoneum or pelvic tissues. The abdomen must be opened. If urine is present in the peritoneal cavity a search must be made for the injured ureters. The general and local condition of the patient will probably be unfavourable for any immediate repair and as a temporary expedient it may be necessary to tie off the ureters, drain the abdomen and establish a nephrostomy on one side.

Peritonitis and pelvic cellulitis

A cut ureter unobserved at operation will give rise to extravasation of urine into the retro-peritoneal tissues and possibly into the peritoneal cavity If the extravasation remains undrained pelvic cellulitis or peritonitis will ensue The condition may be relieved by the spontaneous formation of a urinary fistula through the abdominal wound or vagina. Intravenous pyelography and ureteric catheterization may be needed to clarify the diagnosis Urgent abdominal exploration is required. If at operation urine is found in the peritoneal cavity the cut ureter must be sought. When conditions are suitable it may be re-implanted into the bladder or repaired but if infection is present it should be tied off and repaired at a later operation. When the extravasation is confined to the extra-peritoneal tissues any immediate repair is usually inadvisable and immediate surgical treatment is confined to drainage of this space.

Renal pain

Loin pain following a pelvic operation may indicate obstruction due to ligation of a ureter and unless intravenous pyelography is performed the lesion may be unrecognized. The diagnosis is confirmed by unsuccessful ureteric catheterization. An exploratory and reparative operation should be performed as soon as the patient is well enough and preferably within one month of the injury

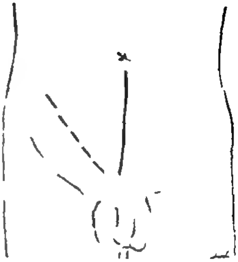
Urinary fistulas

Following pelvic or vaginal operations urinary fistulas are certain evidence of an injury to the ureter or bladder The exact diagnosis is made by a full urinary investigation. Uretero-vaginal fistulas may usually be repaired by re-implanting the lower end of the ureter into the bladder A fistula through an abdominal wound may present great difficulties on account of fibrosis in the extra-peritoneal tissues. Repair may be impossible and nephrectomy finally necessary

THE OPERATIONS

Exposure of the ureter

1 *When the ureteric injury is recognized during* the course of a pelvic operation reparative procedures may be carried out through the peritoneal opening in the floor of the pelvis. At the close of the operation a drain is placed in the extra-peritoneal tissues down to the ureteric anastomosis. The peritoneum of the base of the pelvis is completely closed. As an alternative method the peritoneum of the floor of the pelvis may be closed and the injured ureter exposed by stripping the peritoneum from the side wall of the pelvis.

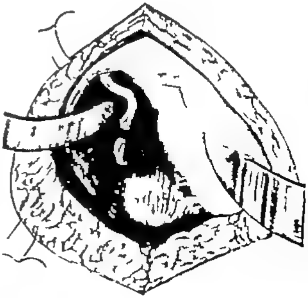


The incision

In carrying out a secondary repair it is desirable to expose the ureter by the extra-peritoneal route. Either a low paramedian or an oblique groin incision may be used. The latter incision is often very useful as it permits an extensive exploration of the ureter and is free of adhesions from the primary operation. The peritoneum is stripped from the side wall of the pelvis and the ureter sought at the point where it crosses the iliac vessels. The ureter is then traced downwards and will be found to disappear into a fibrous mass at the point of injury. If the haematoma formation and fibrosis is recent it may be possible to separate the ureter and even identify an encircling ligature.

Injury at the pelvic brim

2 If the injury is situated at the pelvic brim it should be possible to expose the ureter above and below the fibrotic area. The ends of the ureter are freed and a decision made regarding *the feasibility of ureteric anastomosis or other* methods of repair.

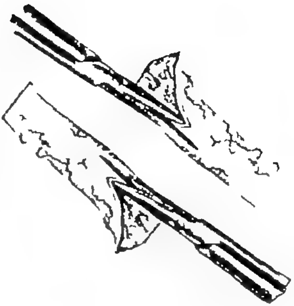


Low pelvic injury

When the lesion is placed low down in the pelvis it may be quite impossible to separate the distal ureter. The ureter is divided just above the injury and mobilized for re-implantation into the bladder.

End-to end anastomosis of the ureter

3-5 The ends of the injured ureter are mobilized so that they may be brought together without tension. Deficiencies of 3–4 cm. may thus be bridged. The ureteric ends are next prepared for anastomosis by dividing them transversely at the first available point which is free of traumatized or fibrotic tissue. To make the anastomosis oblique the circumference of each ureteric end is increased by making a vertical incision in the end of each ureter for 1-1.5 cm. The ends of the ureters are then brought together by two 4/0 plain catgut stitches, each of which passes through the centre of the broad flap of one ureteric end and through the tissue at the apex of the vertical incision of the other. These two stitches are tied and used as stay sutures. The everted ureteric margins are then carefully united with a series of interrupted 4/0 plain catgut stitches, which pass through the full thickness of the ureteric wall. The united ureter should be free from tension and the anastomosis practically watertight. No tube is left in the ureter. A drain is placed in the extra peritoneal tissues down to the ureter and the wound closed. The drain is shortened on the second day and if there is no leakage it may be removed on the third or fourth day.



Alternative procedures

The ureter may be united around a ureteric catheter or Polythene tube, one end of which is inserted up the ureter and the other passed down into the bladder from where it is withdrawn with cystoscopic forceps. The tube serves as a ureteric splint and drain. Such tubes do not prevent leakage and may delay healing and increase the danger of stenosis.

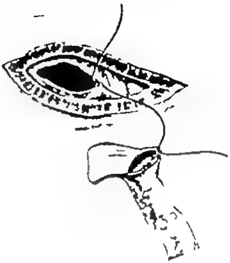
End-in-end and end-to-side anastomoses have been used, but do not permit a large calibre anastomosis.

When a direct anastomosis is impossible, the upper end of the divided ureter has been implanted into the ureter on the opposite side (transuretero-ureteral anastomosis). Such a procedure, however, endangers the remaining normal kidney and ureter and can only be justified under very exceptional circumstances.

Re implantation of the ureter into the bladder

Mucosa-to-mucosa technique

6 *Incision into the bladder*.—At the site of implantation a 3–4 cm. incision is made through the bladder musculature down to the mucosa and is so placed that the ureter may be made to traverse the wall obliquely. The mucosa is incised for 1 cm. at the inner end of the incision. The end of the ureter is prepared for anastomosis by trimming its extremity of damaged or fibrous tissue. The ureter is then incised longitudinally for 1 cm. so as to increase the area of the anastomosis.

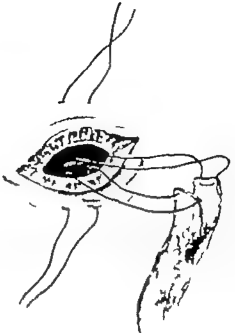


7 *Suture of ureter to bladder mucosa*.—The open end of the ureter is sutured to the mucosa of the bladder with a series of interrupted 4/0 plain catgut sutures, which pass through the full thickness of the ureteric wall and the mucosa of the bladder. The ureter is then laid in the length of the wound and the muscle wall
8 of the bladder is brought together over its distal end by a row of No. 1 plain catgut interrupted sutures. The outer layer of the muscle and the overlying connective tissue are drawn together by a few No. 1 chromic catgut sutures. Care must be taken to avoid constriction of the ureter. The adventitia of the ureter may be joined to the outer surface of the bladder with one or two fine sutures. A soft rubber tube is used to drain the extraperitoneal tissues in the region of the anastomosis for a few days. The bladder is kept empty for 7–10 days by a Foley catheter introduced through the urethra.

Direct technique

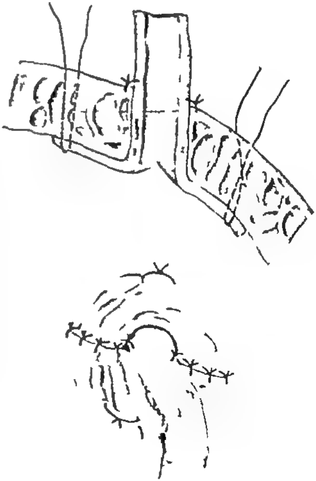
9 *Preparation of the ureter*—The end of the ureter to be re-implanted is divided into equal flaps by two longitudinal incisions, each measuring 1 cm. in length. A mattress suture is inserted in the free end of each flap from the mucosal aspect. Fine curved needles are threaded on to the ends of the sutures.

An incision about 2 cm. long is made through the bladder wall at the site of implantation. The curved needles attached to the mattress suture of one flap are then passed into the bladder and brought out through the full thickness of the bladder wall at about 1 cm. distance from each other and from the margin of the incision. The other flap is then similarly treated.



10 *Insertion of ureter into bladder*—By tightening and tying the mattress sutures the ureter is drawn into the bladder and is held firmly in position by the ureteric flaps attached to the bladder wall. The muscle of the bladder wall is then brought together on either side of the ureter with No 1 plain catgut sutures. The adventitia of the ureter is attached to the outer aspect of the bladder wall with a few 8/0 plain

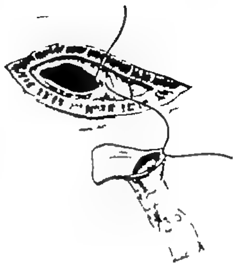
11 catgut sutures. The area of the anastomosis is drained for a few days through a small rubber tube brought out through the extra-peritoneal tissues. Distension of the bladder is prevented for 7–10 days by continuous drainage through a Foley catheter introduced through the urethra.



Re-implantation of the ureter into the bladder

Mucosa-to-mucosa technique

6 *Incision into the bladder*.—At the site of implantation a 3–4 cm. incision is made through the bladder musculature down to the mucosa and is so placed that the ureter may be made to traverse the wall obliquely. The mucosa is incised for 1 cm. at the inner end of the incision. The end of the ureter is prepared for anastomosis by trimming its extremity of damaged or fibrous tissue. The ureter is then incised longitudinally for 1 cm. so as to increase the area of the anastomosis.



7 *Suture of ureter to bladder mucosa*.—The open end of the ureter is sutured to the mucosa of the bladder with a series of interrupted 4/0 plain catgut sutures, which pass through the full thickness of the ureteric wall and the mucosa of the bladder. The ureter is then laid in the length of the wound and the muscle wall

8 of the bladder is brought together over its distal end by a row of No. 1 plain catgut interrupted sutures. The outer layer of the muscle and the overlying connective tissue are drawn together by a few No. 1 chromic catgut sutures. Care must be taken to avoid constriction of the ureter. The adventitia of the ureter may be joined to the outer surface of the bladder with one or two fine sutures. A soft rubber tube is used to drain the extraperitoneal tissues in the region of the anastomosis for a few days. The bladder is kept empty for 7–10 days by a Foley catheter introduced through the urethra.

Direct technique

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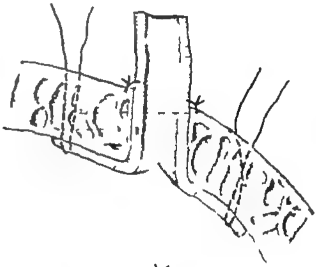
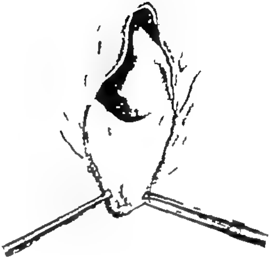


Reconstruction of the lower end of the ureter with a tube-flap from the bladder

Making the flap

12 When the ureter cannot be brought down to the bladder without tension an implantation into a tube-flap raised from the bladder may still be possible.

A rectangular flap about 5 cm. long and 8 cm. wide is cut from the upper surface of the bladder so that when it is turned back the free outer margin comes into easy apposition with the ureter. The flap is cut rather broader at its base than at its distal extremity.



Implanting the ureter

13 The ureter is sutured to the mucosa of the distal extremity of the flap with interrupted 8/0 plain catgut. The flap thus forms a tube around the ureter. The lateral margins of the flap and the bladder wall are then united with an inner layer of No. 1 plain catgut and an

14 outer layer of No. 1 chromic catgut sutures. The adventitia of the ureter is joined to the outer surface of the bladder with a series of fine catgut sutures. As in the previous types of implantation the area of the anastomosis is drained for a few days and the bladder kept at rest by continuous drainage through a Foley catheter in the urethra.

Substitution of a segment of ileum for the lower end of the ureter

When there is a large gap between the lower end of the injured ureter and the bladder a segment of ileum may be used to replace the lower end of the ureter. The replacing loop of bowel may be placed either within or without the peritoneum. When the operation is carried out at the time of the injury it is usually more convenient to use the intraperitoneal route. Two cut ureters may then be implanted into a single loop of ileum. On other occasions it is probably preferable to perform the replacement extraperitoneally.

The Incision

15 When carried out as a secondary reparative procedure the ureter is first exposed extraperitoneally through a long paramedian incision or an oblique incision extending from the twelfth rib to the pubis. The ureter is divided above its point of injury and an estimation made of the length of ileum required to bridge the gap to the bladder.

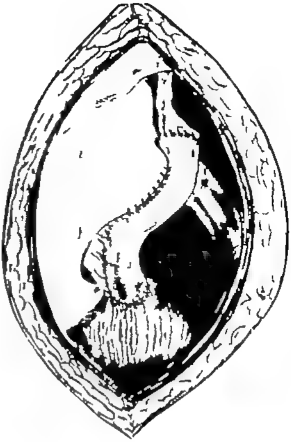
Isolation of ileum

16 The peritoneal cavity is then opened and a suitable segment of bowel is selected from the lower end of the ileum. This segment should not encroach within 15 cm. of the ileo-caecal valve. The mesentery must also be sufficiently long for the bowel to reach the bladder without tension. The loop of bowel is then isolated. Great care is taken to ensure an adequate blood supply to the segment and to obtain as broad a pedicle as possible. The intestine is then united either by an end-to-end or side-to-side anastomosis, which may be placed either in front or more rarely behind the isolated loop.

The ileo-ureteric anastomosis

17 If the replacement is to be extra-peritoneal the isolated loop of ileum is passed through an opening made in the lateral wall of the pelvic peritoneum and is swung into position. On the left side the proximal end of the loop comes naturally into apposition with the lower end of the ureter On the right side in order to avoid twisting the mesentery of the loop it is necessary to unite the ureter to the distal end of the loop The presence of an antiperistaltic segment in the ureter does not appear to interfere with drainage (Pyrah, 1955) By incising the end of the ureter longitudinally to increase its circumference a direct anastomosis may be made between the ureter and the loop of ileum. The risk of considerable pressure arising in the loop during micturition and being transmitted up the ureter to the kidney has led some surgeons to prefer an indirect type of anastomosis.

The lower end of the ileum is united to the bladder at a suitable site by a two layer anastomosis. The opening in the pelvic peritoneum is closed by a layer of sutures attaching it to the wall of the segment of ileum.



[The illustrations for this Chapter on Injuries to the Ureter were drawn by Miss J Perry]

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INJURIES TO THE BLADDER

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Lecturer in Urology, the University of Manchester; Urologist to Salford Royal Hospital, the Christie Hospital and Holt Radium Institute, the Royal Manchester Children's Hospital and Crumpsall Hospital, Manchester

PRINCIPLES OF TREATMENT

The primary aim of treatment is to close the wound in the bladder and establish adequate vesical drainage during the period of healing. Extravasated urine is removed and provision is made for drainage of the perivesical tissues. Every effort is made to avoid continued leakage from the bladder, stagnation of urine in the tissues and the introduction of infection. The latter precautions are particularly important when the pelvis is fractured.

RUPTURE OF THE BLADDER

Rupture may occur following a fall or heavy blow to the abdomen when the bladder is full. More commonly it is the result of an injury causing disruption of the pelvic girdle.

The patient presents as a case of abdominal or pelvic injury. Clinical examination may leave doubt as to the exact diagnosis and may fail to differentiate between intraperitoneal and extraperitoneal rupture of the bladder and a tear of the posterior urethra. Double lesions are also not very uncommon. A blow which has fractured the pelvis and caused an extraperitoneal perforation may also rupture a distended bladder intraperitoneally. An extraperitoneal rupture may be accompanied by a tear of the posterior urethra. Other intraperitoneal lesions may also be present.

Pre-operative investigations

Rupture of the bladder requires urgent operative treatment and pre-operative investigations should therefore be confined to relatively simple procedures and not allowed to cause undue delay. A straight radiograph of the lumbar spine and pelvis will demonstrate the extent of pelvic fractures and dislocations. A catheter may be passed under full aseptic precautions. If it slips into the bladder easily and if a little blood-stained urine drains away a rupture of the bladder is probable. The injection and attempted withdrawal of measured quantities of fluid is liable to be a fallacious test. Occasionally a cystogram made by injecting 100 ml. of a non-irritating radio-opaque solution (10 per cent Skiodan or Pyelectan) into the bladder may be of real help. Cystoscopy is not a satisfactory diagnostic procedure. If the rupture is large the bladder will not distend satisfactorily and the contained fluid tends to be hazy with blood. A small vesical tear may easily be missed unless the bladder is fully distended and the medium crystal clear.

Exploratory operation

Anaesthesia.—General anaesthesia is required, with full relaxation of the abdominal muscles.

The incision.—The peritoneum and prevesical area are explored by a mid-line suprapubic incision. If there is any suspicion of an intraperitoneal lesion the peritoneal cavity is opened.

INTRAPERITONEAL RUPTURE

The peritoneal cavity having been opened any free urine and blood are removed by suction and mopping. The abdominal viscera are examined and the small bowel then packed into the upper abdomen with warm swabs. The peritoneal surface of the bladder is examined. The rupture is usually small. Its margins are seldom severely lacerated and their excision may not be necessary. The rupture is closed with an inner continuous layer of No. 1 plain catgut sutures and an outer layer of No. 1 chromic catgut. The peritoneal cavity is closed without drainage. A small drain is placed in the prevesical space and the wound closed. The bladder is drained by an indwelling urethral catheter.

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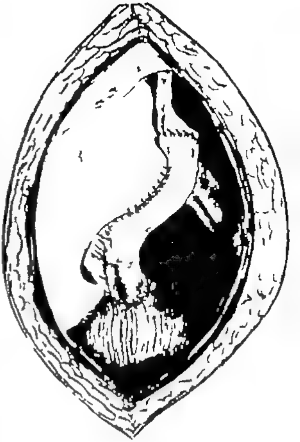

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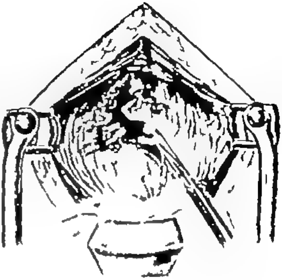
EXTRAPERITONEAL RUPTURE

Location of the wound

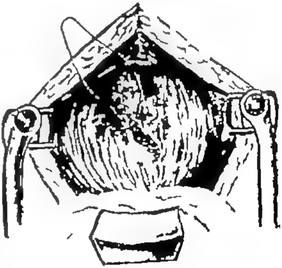
1 An extraperitoneal rupture is usually accompanied by fractures or a dislocation of the pelvis. Urine and blood will be found welling up from behind the pubis. The anterior bladder wall may be grossly contused and difficult to identify. In these circumstances a sound passed up the urethra will help to identify the margins of the tear in the bladder. If difficulty is found in locating a small tear the bladder may be opened between stay sutures and explored from within. The bladder neck and anterior surface of the prostate are also carefully examined to exclude a tear of the posterior urethra. The margins of the rupture are then lightly trimmed with scissors to remove excessively traumatized tissue.



Repair of the rupture

2 A complete closure of the bladder wall is usually possible. A Foley catheter (20 F., 5 ml. bag) is passed up the urethra and fixed in position to provide continuous bladder drainage. The bladder wall is then sutured with an inner continuous layer of No 1 plain catgut, which picks up the muscle of the bladder wall on either side, and an outer layer of No 1 chromic catgut, which approximates the outer muscle layers and the overlying connective tissue. A soft rubber tube drain is placed in the retropubic space and the suprapubic wound closed.

When the laceration of the bladder wall is gross it may be advisable to leave a suprapubic drain in position. A Malecot catheter is introduced into the bladder either at the top of the laceration or through a separate stab incision at a higher level. The bladder wall is then closed in two layers. A drain is placed in the prevesical space and the abdominal wall closed around the catheter which is brought out at as high a level as possible.



POST-OPERATIVE CARE

Bladder lavage

At the close of the operation the bladder is washed out through the indwelling urethral catheter so as to make sure that the bladder is free of blood and clot. The penis and proximal portion of the catheter are then enclosed in a sterile dressing so as to prevent infection travelling up the catheter. The catheter is connected by a sterile rubber tube to a collecting bottle by the side of the bed. Thereafter no further bladder lavage is carried out unless the catheter appears to be draining badly. The patient is given a suitable course of antibiotics to guard against infection.

Removal of drain

The prevesical drain is removed in 2–3 days. If progress is satisfactory the indwelling urethral catheter is removed in 7–10 days and normal micturition commenced. When suprapubic drainage has been used the tube may be removed in 5–7 days and the bladder drained by an indwelling urethral catheter until healing is complete.

PENETRATING INJURIES

The bladder may be damaged by a gunshot wound or stabbing injury. The perforation of the bladder may be only one of many severe lesions for the missile may also have penetrated the peritoneal cavity, perforated the rectum or shattered portions of the pelvic girdle. The amount of damage to the bladder is very variable. A bullet may traverse the bladder leaving only a minute entry and exit wound, whilst a fragment of shell or bomb may tear a large opening and destroy much bladder wall.

Examination of superficial wounds

An examination and toilet of the superficial wounds is first made. When an entrance and exit wound are present they provide a valuable guide to the course of the missile and to possible damaged structures. A urethral catheter is next passed as a diagnostic procedure, and will help to distinguish between a wound of the bladder and an injury to the prostatic or bulbous urethra. The abdomen is then explored through a mid-line suprapubic incision. The peritoneal cavity is opened. Any free blood and fluid are removed and the viscera searched for injuries. If an intraperitoneal perforation of the bladder is present the margins are excised and the wound closed in two layers. When there is evidence of either an intraperitoneal or extraperitoneal injury to the rectum a left iliac colostomy is established at this stage. The peritoneum is then closed without drainage. The bladder is next exposed in the suprapubic region and if there is no evidence of an extraperitoneal wound it is opened anteriorly between stay sutures. A careful search is made for injuries and any foreign bodies or loose fragments of bone are removed. The subsequent course depends on the degree of vesical damage. Whenever possible the vesical wounds are excised and sutured. In civil life many missile perforations of the bladder may be treated by complete closure of the bladder, drainage of the retropubic space, and continuous evacuation of the bladder through an indwelling urethral catheter. In war meticulous after-care may be lacking and long distance evacuation necessary. Under such circumstances an indwelling urethral catheter is unsafe and suprapubic drainage of the bladder is essential. In these circumstances the exploratory opening into the bladder is closed around a Malecot catheter (24–28 Charrière), which is brought out at the top of the bladder incision and as high in the suprapubic wound as possible. A soft rubber tube is used to drain the retropubic space.

Wounds of the vault

Wounds of the vault of the bladder usually present no difficulty to close. The bladder wall is freely mobile and the margins may be easily approximated even after wide excisions.

Wounds of the anterior and lateral walls

Injuries to the upper portions of the anterior and lateral walls may be easily closed. Difficulties may arise when the bladder wound is low down and is accompanied by shattering of the pelvis and an open wound in the pubic or groin regions. A considerable area of bladder wall may be destroyed and contusion of the tissues may make identification of the limits of the vesical wound difficult. The base of the bladder is also relatively fixed and difficulty may be experienced in bringing the wound margins together In such circumstances a tense suture line may break down and allow infected urine to drain into the perivesical tissues and into the pubic fractures causing chronic osteomyelitis. The margins of the vesical wall become adherent to the pelvic wall and if the superficial wound has given way a permanent urinary fistula is established.

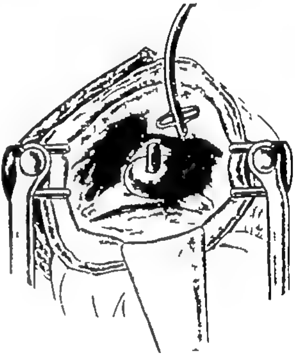
To avoid such troubles every effort must be made to close the bladder as satisfactorily as possible and to drain the urine from the bladder as rapidly as it is secreted.

ARRANGEMENTS FOR DRAINAGE

3 A Foley catheter (20 Charrière—5 ml. bag) is passed up the urethra to drain the base of the bladder Suprapubic drainage is also established by passing a Malecot catheter (24–28 C) into the bladder either through the upper portion of the wound when it is large or more commonly through the exploratory incision in the anterior wall of the bladder The bladder wounds are then closed as completely as possible and the perivesical tissues drained.

Suction drainage

By attaching a low negative pressure suction apparatus to the Foley catheter the urine may be continuously aspirated. The Stedman electric pump is very suitable for this purpose. When suction is being employed it is highly advantageous to arrange the suprapubic tube so that it may act as an inlet vent for air The bladder suction is then continuous and no undesirable negative intravesical pressure develops.



Wounds of the base of the bladder

Owing to the fixity of the tissues it is usually impossible to suture wounds of the base of the bladder satisfactorily and more harm than good may result from attempting to do so Provided a colostomy has been established a very high proportion of rectovesical fistulas will heal spontaneously When a ureteric orifice has been damaged it is usually unwise to attempt any wide exposures of the ureter and reimplantation into the bladder The ureter will drain through the wound into the bladder If any ureteric obstruction ensues a formal exploration and reimplantation may be performed at a later date.

SURGICAL INJURIES OF THE BLADDER

Injuries occurring during open operations

When the bladder is injured during the course of a pelvic or vaginal operation the opening is usually small and the surrounding tissue undamaged. Injury has been caused during labour but this is now rare where adequate maternity services exist. Closure is effected with two layers of catgut sutures and the bladder drained by an indwelling urethral catheter

Transurethral injuries

When the bladder wall is seriously weakened by disease penetration may occasionally occur during the course of a cystoscopy More commonly perforation is the result of the transurethral treatment of intravesical lesions or of transurethral resection of the prostate or bladder neck. The result of such a perforation may be extremely serious. Much fluid may have been forced out under pressure from the bladder into the perivesical tissues or peritoneal cavity If infection has been present in the bladder due to the primary lesion a gross septic extravasation may be present.

When the diagnosis of perforation is in doubt and provided there is no pyogenic infection in the urinary tract, it is justifiable to drain the bladder continuously through a Foley catheter inserted through the urethra, to place the patient on a full protective course of antibiotic drugs and to keep him under close observation. A retrograde cystogram may help to clarify the diagnosis but filling of the bladder should be limited to 100 ml. Under such treatment small perforations may heal If there is any deterioration in the patient's condition an immediate suprapubic exploration must be carried out

When the diagnosis of perforation is more definite and certainly in the presence of a urinary infection, immediate abdominal exploration is indicated. The site of the treated vesical lesion will give an indication as to the probability of an intraperitoneal or extraperitoneal perforation, but whenever doubt exists the peritoneal cavity should be exposed and any perforation closed. If the perforation has resulted from a resection of the bladder neck there will probably be considerable extravasation and haemorrhage in the retropubic region. The bladder is opened anteriorly between stay sutures and the amount of damage to the bladder neck assessed. Whenever possible the perforation is closed with sutures, but if the resection has been extensive this may be difficult. Owing to the possibility of further leakage and haemorrhage it is usually advisable to drain the bladder suprapubically The opening in the anterior bladder wall is therefore closed around a Malecot catheter which is brought out high up in the suprapubic wound. A small soft rubber tube is used to drain the retropubic space

[*The illustrations for this Chapter on Injuries to the Bladder were drawn by Miss J Perry*]

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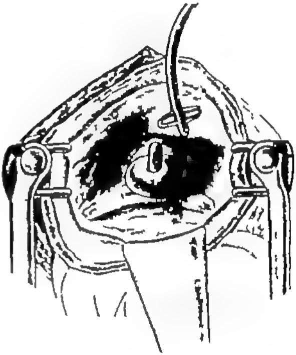

Wounds of the base of the bladder

Owing to the fixity of the tissues it is usually impossible to suture wounds of the base of the bladder satisfactorily and more harm than good may result from attempting to do so. Provided a colostomy has been established a very high proportion of rectovesical fistulas will heal spontaneously. When a ureteric orifice has been damaged it is usually unwise to attempt any wide exposures of the ureter and reimplantation into the bladder. The ureter will drain through the wound into the bladder. If any ureteric obstruction ensues a formal exploration and reimplantation may be performed at a later date.

SURGICAL INJURIES OF THE BLADDER

Injuries occurring during open operations

When the bladder is injured during the course of a pelvic or vaginal operation the opening is usually small and the surrounding tissue undamaged. Injury has been caused during labour but this is now rare where adequate maternity services exist. Closure is effected with two layers of catgut sutures and the bladder drained by an indwelling urethral catheter

Transurethral injuries

When the bladder wall is seriously weakened by disease penetration may occasionally occur during the course of a cystoscopy More commonly perforation is the result of the transurethral treatment of intravesical lesions or of transurethral resection of the prostate or bladder neck. The result of such a perforation may be extremely serious. Much fluid may have been forced out under pressure from the bladder into the perivesical tissues or peritoneal cavity If infection has been present in the bladder due to the primary lesion a gross septic extravasation may be present.

When the diagnosis of perforation is in doubt and provided there is no pyogenic infection in the urinary tract, it is justifiable to drain the bladder continuously through a Foley catheter inserted through the urethra, to place the patient on a full protective course of antibiotic drugs and to keep him under close observation A retrograde cystogram may help to clarify the diagnosis but filling of the bladder should be limited to 100 ml. Under such treatment small perforations may heal. If there is any deterioration in the patient's condition an immediate suprapubic exploration must be carried out.

When the diagnosis of perforation is more definite and certainly in the presence of a urinary infection immediate abdominal exploration is indicated The site of the treated vesical lesion will give an indication as to the probability of an intraperitoneal or extraperitoneal perforation but whenever doubt exists the peritoneal cavity should be exposed and any perforation closed If the perforation has resulted from a resection of the bladder neck there will probably be considerable extravasation and haemorrhage in the retropubic region. The bladder is opened anteriorly between stay sutures and the amount of damage to the bladder neck assessed. Whenever possible the perforation is closed with sutures, but if the resection has been extensive this may be difficult. Owing to the possibility of further leakage and haemorrhage it is usually advisable to drain the bladder suprapubically The opening in the anterior bladder wall is therefore closed around a Malecot catheter which is brought out high up in the suprapubic wound. A small soft rubber tube is used to drain the retropubic space.

[*The illustrations for this Chapter on Injuries to the Bladder were drawn by Miss J Perry*]

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INJURIES TO THE URETHRA

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INTRODUCTION

In civil life injuries to the urethra are rarely accompanied by an open wound. The most common lesions are ruptures of the bulbous and of the posterior urethra. The penile urethra is rarely damaged. Occasionally during a violent accident a foreign body such as a gear lever may penetrate the perineum and sever the urethra. More commonly the open injuries are the result of gunshot or knife wounds. Such injuries occur at any level in the urethra and the lesion is less frequently complete. Apart from the toilet and repair of the external wounds their treatment corresponds closely to that of the ruptured bulbous and posterior urethra.

Sequelae of urethral injuries

The mortality resulting from injuries to the urethra should be low Death is usually the result of delayed treatment or of severe concomitant injuries. Stricture formations, urinary fistulae and chronic urinary infection may be troublesome and at times unavoidable sequalae. Inadequate treatment markedly increases this morbidity rate.

Causes of stricture formation

Wounds of the urethra heal by the formation of scar tissue and some degree of narrowing of the urethral channel is therefore inevitable. Treatment is directed to reducing fibrosis at the line of union to a minimum so as to avoid any appreciable stricture formation

There are four main causes of stricture formation

Severity of the primary lesion

Considerable necrosis may occur in the lacerated urethral tissues and give rise to fibrosis. Pasteau and Iselin (1906) and Kidd (1921) have pointed out the difficulty of determining the limits of tissue necrosis, which may follow pulping and laceration of the bulbous urethra. These authors stress the importance of endeavouring to remove all non-viable tissue prior to carrying out an end-to-end suture.

Inadequate approximation of the severed urethral ends

Careless approximation and suturing may give rise to unnecessary scar formation.

Sepsis at the site of injury

Sepsis may ruin the most meticulous repair and cause increased necrosis and scar formation. The infection may be introduced by careless catheterization or by the inadequate care of wounds. Urine flowing over a wound and the presence of an indwelling urethral catheter encourage the onset of infection.

Damage by injudicious dilatation

The healing urethra may be damaged by too frequent and too vigorous dilatation.

Principles of treatment

In the past there has been much divergence of opinion regarding treatment. The following guiding principles are now widely accepted. (1) Urine must be diverted from the damaged urethra until healing is complete. (2) The severed ends of the urethra must be brought into good apposition. (3) Whenever possible the use of an indwelling urethral catheter is avoided during the period of healing (4) Sepsis must be avoided. (5) Subsequent dilatation must not cause further damage to the urethra.

RUPTURE OF THE BULBOUS URETHRA

PRE-OPERATIVE

Indications for operation

When definite signs and symptoms of a rupture are present (localized pain, meatal bleeding, perineal haematoma, retention of urine) immediate surgical intervention is necessary.

If a patient, following a perineal injury of sufficient severity to have caused meatal bleeding, is found on examination to have already passed urine and shows no sign of a perineal haematoma or swelling it may be concluded that the urethra has been contused but that neither a complete nor incomplete rupture is present. Operative treatment is not indicated but the patient is kept under close observation.

Nature of the operative procedure

Many methods of treatment have been used. The following procedure is recommended. (1) The urethra is gently catheterized to determine if the rupture is complete or incomplete. (2) Suprapubic cystostomy is performed to divert the urine from the urethra. (3) If the rupture is incomplete perineal exploration is not required. The continuity of the urethra is present and it is unlikely that suture of the incomplete tear will improve on natural healing. When a large perineal haematoma is present it should be evacuated. (4) If the rupture appears to be complete the perineum is explored and a repair performed.

Immediate repair of the urethra is usually desirable. If the patient's general condition is poor, if the surgeon is inexperienced in urethral repair or lacks adequate facilities for a meticulous operation, the urine may be diverted from the urethra by a suprapubic cystostomy and the urethral repair carried out either in the course of the next few days or even in 6–8 weeks when the perineal contusion will have subsided.

Anaesthesia

For perineal exploration bleeding must be reduced to a minimum. Venous congestion must be avoided. A spinal anaesthetic with a slight head-down tilt and a sleeping dose of thiopentone are very suitable. General anaesthesia may be used.

URETHRAL CATHETERIZATION AND ESTABLISHMENT OF SUPRAPUBIC DRAINAGE

Catheterization of the urethra may be carried out after the patient has been placed in position for a urethral repair. Some surgeons may prefer to perform this step as an initial procedure with the patient lying flat.

A Tiemann's catheter (10 or 12 Charrière) is passed gently into the urethra with its tip directed towards the roof. If any obstruction is met the catheter is slightly withdrawn and then advanced again with its tip in a slightly altered direction.

Incomplete rupture

Successful passage of the catheter into the bladder indicates that continuity of the urethra is present and that the rupture is incomplete. Suturing of the incomplete tear is unlikely to improve on natural healing and there is therefore no need for perineal exploration. If a severe stricture ensues a maximum of urethral tissue has been saved for subsequent repair. The urethral catheter is withdrawn. A suprapubic cystostomy is performed to divert the urine from the urethra. If a large perineal haematoma is present it should be evacuated.

Complete rupture

If catheterization is unsuccessful either a complete or severe incomplete rupture is present. Continuity of the urethra has not been proven and the urethra should therefore be explored and repaired. As an initial step the bladder is opened through a short suprapubic incision so as to permit retrograde catheterization of the urethra and the subsequent establishment of suprapubic drainage.

THE OPERATION

Position of the patient

1 The patient is placed in a modified Trendelenburg lithotomy position, which is very similar to that used for synchronous combined excision of the rectum. A rubber pad is placed under the buttocks to raise the perineum from the table. The legs are held in position by gutter thigh and calf supports, which are mounted on ball and socket joints. The thighs should be fairly well abducted but only slightly flexed. In this position the perineal tissues are relatively relaxed. Excessive flexion of the hips places the perineum under tension and causes wide separation of incised tissues with consequent difficulty in suturing. The abdomen, external genitalia and perineum are cleaned and towelled so as to permit the carrying out of the suprapubic and perineal stages of the operation without any change in the position of the patient.

Exposure of the bulbous urethra

2 The skin and superficial tissues of the perineum are incised in the midline. Subcutaneous blood clot is gently removed and an attempt made to identify the anatomical structure amongst the contused tissues. The bulbo-cavernous muscle is divided along the median tendinous raphe and the urethra exposed. A metal sound passed up the anterior urethra may be used as a guide and if gently advanced into the wound will indicate the site of the rupture. The urethra is carefully examined to determine if the rupture is complete or incomplete and the amount of damage to the urethral tissue is assessed.

Identification of the divided urethra

3 When the rupture is incomplete a small Tieman's catheter is passed up the urethra and is guided on into the bladder. If the margins of the urethral tear are ragged they may be lightly trimmed and are then brought together over the in-lying catheter with fine interrupted 3/0 plain catgut sutures. The stitches should pass through the mucosa and full thickness of the corpus spongiosum. If the severity of the urethral damage renders suturing difficult it may be advisable to make the rupture complete, to mobilize and trim the divided urethral ends and to perform a complete end-to-end suture.

When the rupture is complete the urethral ends may be lost in the contused tissues. The distal extremity is easily demonstrated by a sound passed up the urethra. The proximal end may be very difficult to find and a bougie passed down the urethra from the open bladder may save much time and trouble in its identification.

Repair of the urethra

4 The divided ends of the urethra are lightly trimmed to remove contused tissue and mobilized sufficiently to allow them to be brought together without tension. The posterior wall is then united with two or three 3/0 plain catgut sutures, which pass through the mucosa and corpus spongiosum.

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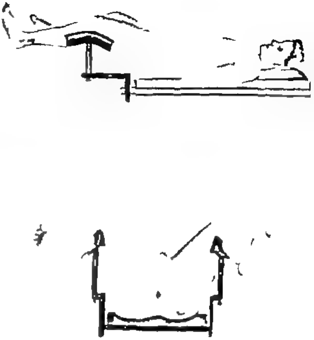

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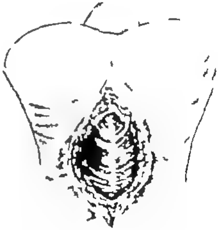

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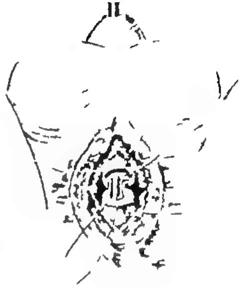
Suture of the divided ends

5

A small Tieman's catheter is now passed up the urethra, across the rupture and on into the bladder. This catheter steadies the urethra during the completion of the repair and facilitates accurate approximation of the divided ends. The suturing of the urethral margins is completed with a series of evenly placed 8/0 plain catgut stitches, which pass through the full thickness of the urethral wall. If the repair appears satisfactory the urethral catheter is withdrawn so that no foreign body remains in the urethra during healing.

When the damage to the urethra is severe it may be impossible to determine the limits of viability of the crushed urethral tissues. Difficulty may also be experienced in bringing the divided ends together. With extensive mobilization of the urethral ends it is possible to bridge defects of 4–6 centimetres. In the presence of fresh trauma such wide dissections are undesirable and may only result in still further devitalizing already damaged tissues. It is most important that at the primary operation nothing should be done which may render a good urethral repair at a later date impossible. In such circumstances the urethral ends are aligned over a small indwelling urethral catheter which is left in position as a urethral splint. No suturing is attempted.

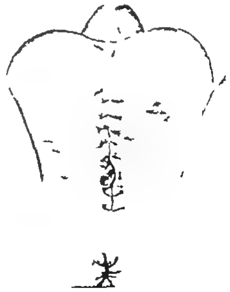


Repair of the perineal and suprapubic wounds

6

The bulbo-cavernous muscle is brought together with interrupted catgut sutures. A small rubber drain is placed in the perineum and the subcutaneous tissues brought together with fine plain catgut sutures. The skin margins are approximated with thread or nylon sutures.

The bladder is then closed around a Malecot catheter (20 Charrière). A drain is placed in the cave of Retzius and the suprapubic wound closed.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

To assist healing it is essential to avoid tension on the perineal tissues and the occurrence of erections. The patient is kept almost flat in bed and the thighs are moved as little as possible. Restlessness due to pain must be avoided and may be relieved with pethidine (100 mg. intramuscularly as required). Oestrogens (stilboestrol 10 mg. or dienoestrol 10 mg. 8-hourly) are given to control erections. A mixture containing potassium bromide 15 gr., chloral hydrate 15 gr. and Nepenthe 15 min. to the half ounce, when given 8-hourly helps to produce a state of drowsiness and to prevent penile turgidity.

Dressings

The genital and perineal regions must be kept as sterile as possible. Dressings in this region are prone to come adrift. They may be firmly held in position by a length of Gamgee tissue which is shaped and fitted to extend from the waist posteriorly, down over the buttocks, between the legs and up over the perineum on to the abdominal wall. A many-tailed abdominal binder with perineal straps is placed over the Gamgee tissue.

Urinary antiseptics

Procaine penicillin (300 000 units) and streptomycin (1 g.) are given 12-hourly for the first 2 weeks. If there is any sign of urinary infection, the sensitivity of the organisms to the sulphonamides and other antibiotics is ascertained and the appropriate treatment given. Urinary antiseptics are continued for at least 6 weeks or until the urine remains clear.

Suprapubic cystostomy

Drainage from the suprapubic catheter must be kept absolutely free so as to keep the bladder empty and minimize the danger of urine passing down the urethra. When drainage is satisfactory routine bladder lavage is avoided.

Cessation of suprapubic drainage

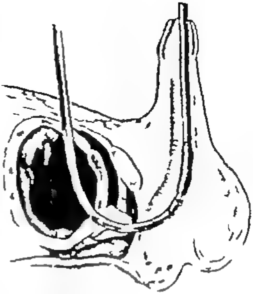
No definite time can be laid down for removal of the suprapubic tube. Drainage is continued until the perineal wound is soundly healed. Usually in about 2–2½ weeks gentle urethral bouginage is carried out under thiopentone anaesthesia and a muscle relaxant. If the urethral channel is satisfactory and after the elapse of 2–3 days to allow any local irritation due to the bouginage to subside, a spigot is placed in the suprapubic catheter and the patient encouraged to micturate through his urethra. If there is any leakage of urine from the perineal wound suprapubic drainage is continued but if after a few days the perineum remains absolutely dry then the suprapubic catheter is removed and the wound allowed to heal. Leakage from the cystostomy opening is usually slight as the track to the bladder should be oblique and the patient has already relearnt to micturate. An indwelling urethral catheter is never used to aid closure of the suprapubic wound for it is unwise to run the risk of starting even the mildest urethritis.

Dilatation of the urethra

The first bouginage is carried out about 2½ weeks after the repair. The urethra is gently explored with the patient completely relaxed under thiopentone anaesthesia. Local urethral anaesthesia may be used for subsequent examinations. Their frequency will depend on the degree of stricture formation. In a satisfactory case instrumentation may be performed at intervals of 2, 4 and 8 weeks and finally at periods of 3, 6 or 12 months. The type and size of instruments required will depend on the individual stricture. Over-dilatation must be avoided.

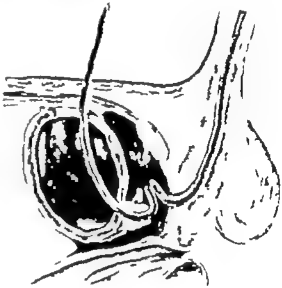
Joining the Foley and Tieman catheters

10 The tip of a Foley catheter is now attached to the distal end of the Tieman's catheter with a stitch and is drawn through into the bladder. In addition to distending the Foley bag it is useful to hold the catheter in position by a thread stitch which is passed through its tip and is then attached to a rubber tube on the abdominal wall. *With this stitch in position it is possible at any time to draw a fresh catheter into position*



Two catheter method

11 If the previous methods fail this technique may be used. A soft rubber catheter is passed in a retrograde manner so that its tip emerges from *the prostatic urethra. A Foley catheter is then* passed from the penis until it emerges in the pelvic floor. The tips are joined by a stitch and the Foley catheter is drawn through into the bladder

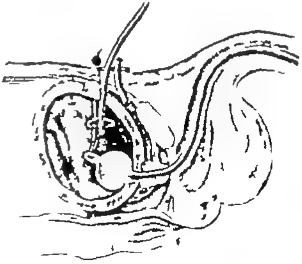


Suprapubic drainage

12 When the Foley catheter is safely in position an attempt may be made to unite the divided urethra with a few sutures. The tissues are however usually grossly infiltrated with blood and no accurate suturing is possible. The bladder is then closed around a Malecot catheter which acts as a suprapubic drain. The retropubic space is drained and the abdominal wall closed.

Other modes of repair

Young has used a perineal exposure for the repair of the ruptured posterior urethra. More recently Hunt and Morgan have obtained accurate end-to-end suture of the divided posterior urethra by using a combined abdominal and perineal approach



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

The fractured pelvis

The treatment of the fractured pelvis must be planned in conjunction with an orthopaedic surgeon. Separation of the pelvic girdle may be temporarily controlled with a tight binder. A counter-balanced pelvic sling giving slight medial pressure is frequently both helpful and comfortable.

The urethral catheter

The urethral catheter is left in position for at least 2 weeks and certainly until any accompanying fracture-dislocation of the pelvis is reasonably stable. A few days after its removal a spigot is placed in the suprapubic tube and the patient allowed to try and pass urine per urethram. As soon as micturition is satisfactory the suprapubic drain is removed and the cystostomy allowed to close.

Urethral dilatation

Urethral dilatation is always necessary. When all goes well it is carried out at increasing intervals of weeks until finally only 6-monthly or annual treatment is required.

When the trauma has been severe or pelvic infection present considerable stricture formation may occur despite the most careful treatment. Gross peri-urethral fibrosis and distortion of the urethral tract due to incomplete reduction of the pelvic fractures may give rise to difficulty in dilatation. Difficulty in micturition and chronic urinary infection may then become very troublesome.

[The illustrations for this Chapter on Injuries to the Urethra were drawn by Miss J. Perry.]

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PENETRATING WOUNDS OF THE CHEST

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PRE-OPERATIVE

Indications

Sucking wounds should have been already sealed with an occlusive dressing to save life as a first aid measure. The surgeon's task is now to prevent infection by excision of the wound of the chest wall to remove any easily accessible foreign body to evacuate blood clot, to expand the lung if possible, and to close the chest. The principle of drainage in infected wounds must be modified, for at all costs the pleural cavity must be closed. Only then can drainage be carried out by intercostal tube to a water-sealed drainage bottle, or intermittent drainage can be given by aspiration.

Special contra-indications

Tiny fragments of metal from high explosives, sometimes multiple, may enter the chest with minimal trauma to the parietes and no obvious sign of a sucking wound. In the Western Desert in the years 1941–42 there were many perforating bullet wounds in which the bullet traversed the lung but left a clean sterile track through the chest wall. Such tiny wounds do not need excision in fact wide excision of such minimal wounds may only produce a sucking wound, which was not previously present.

Bombs and high explosives often cause multiple haematomas and oedema in both lungs, irrespective of the actual fragment which penetrates the lung Such a patient with a "traumatic wet lung" is a most difficult subject for a general anaesthetic because of the obstruction of the air passages by blood and watery fluid. Operation on small wounds in these cases should be delayed for a few hours, unless they are sucking

Pre-operative preparation

Assuming that any sucking wound is temporarily closed with a dressing, it is best to relieve the patient's dyspnoea by aspirating the pleural cavity to allow blood or air under tension to escape. This will promptly correct mediastinal displacement and make the anaesthetist's task easier Anoxia will be relieved both by oxygen and blood transfusion It is well to remember that the anoxia is often partly due to loss of haemoglobin.

Anaesthesia

General anaesthesia, with control of the lung by inflation and aspiration of secretions, is necessary

Without proper control and inflation of the lung by the anaesthetist, it is only too easy for the surgeon to make things worse by causing a complete collapse of the lung by his intervention.

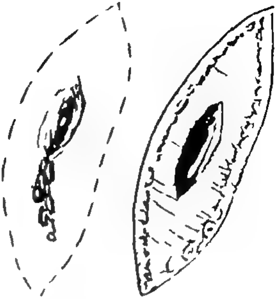
Position

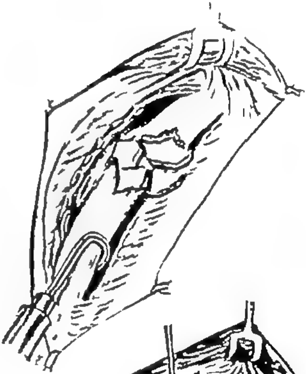
Though the lateral position is most convenient for the surgeon, the supine or prone is better for the patient, for there is less risk of blood being aspirated into the contra-lateral lung

THE OPERATION

Excision

1 The wound is gently explored with a probe. Rib fragments are felt. Only the skin edges, not more than one-eighth of an inch, are excised. Debris and damaged muscle is removed, until healthy muscle tissue is encountered. The skin wound may then be extended to display the compound comminuted fracture of the rib.





Stripping the periosteum

2 The periosteum is stripped from both ends of the fractured rib with a sharp raspatory; then a Doyen raspatory clears the back of the rib.

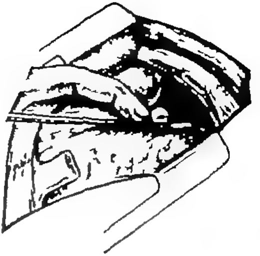
Resection of the injured rib

3 A costotome now cuts through healthy rib so that the compound fracture is resected en bloc or in pieces. The intercostal artery and veins are ligated. The nerve, if intact, is carefully preserved.

4

Search for penetration into the pleural cavity

If a missile has penetrated the pleural cavity and is retained in the pleural space, then a quick search for it should be made. Empyema often follows retention of such bodies loose in the pleural space. The missile when found is removed, blood and clots are sucked out of the pleural cavity, the anaesthetist does his best to inflate the lung and the chest is now closed.



5

Closure of the underlying tissues

The pleura, periosteum and intercostal muscles are sutured in one layer with interrupted catgut. Penicillin–sulphonamide powder is dusted into the wound. The chest wall muscles are then sutured with interrupted catgut stitches. If much muscle has been resected, it may be necessary to mobilize muscles to cover the defect in the chest wall. A sound airtight closure of the pleural cavity is essential; it is most difficult to achieve in anterior wounds, involving the cartilages, where the muscles are thin or absent.

The skin and subcutaneous tissues are left open for drainage, to be closed by delayed primary suture in forty-eight hours if there is no infection. A dressing of Vaseline gauze seals the superficial wound. Finally, if blood or air remain in the pleural space, they should be aspirated repeatedly until the lung is fully expanded.

POST-OPERATIVE CARE

The post-operative management of the patient and the complications which may arise following surgical intervention are dealt with at the end of the Chapter on Injuries to the Oesophagus (page 100)

[*The illustrations for this Chapter on Penetrating Wounds of the Chest were drawn by Miss Dorothy Davidson.*]

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SURGERY OF RETAINED MISSILES IN THE LUNG

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PRE-OPERATIVE

Indications for removal

Metallic fragments, which were sterile because hot on entry cause less infection than the accompanying bits of bone rib fragments or clothing but large fragments, bigger than 1 cm., frequently cause haemoptysis and infection. If near the larger pulmonary vessels near the hilum such fragments may cause fatal secondary haemorrhage. Unfortunately therefore those missiles most likely to cause serious trouble are near the lung root and are difficult to remove those situated more peripherally in the lung are easy to remove but much less likely to cause trouble.

Indications for resection of lung

Absolute indications to resect are to control haemorrhage or leakage of air if simple suture techniques have failed. Such cases are rare the lobe is so lacerated that the need for its removal is obvious. Late sepsis, bronchiectasis and lung abscess, secondary to a retained missile are other indications for resection.

Localization of the missile

Skin markings so useful in localizing missiles in muscle are of no value once the fragment has penetrated the thorax. For when the chest is opened, the fragment in the lung may fall away from the marker on the chest wall as the lung deflates. Postero-anterior and lateral radiographs will locate the majority of fragments with accuracy Missiles which are difficult to localize are those on the diaphragm screening may here be helpful in determining whether the fragment is above or below it. One source of error which should be remembered is due to the radiologist taking his films with the patient erect and the lungs in full inspiration the surgeon operates on a recumbent patient whose lungs are not so fully distended Therefore, a missile which appears to lie as low as the tenth rib on the radiograph is usually found to be a rib higher at operation.

Finally it is essential to take one radiograph immediately before operation I know at least one surgeon who was dumbfounded to find that the missile had "gone" when the chest was opened but it was in the pulmonary artery and had slipped over to the opposite side from which it was later successfully removed.

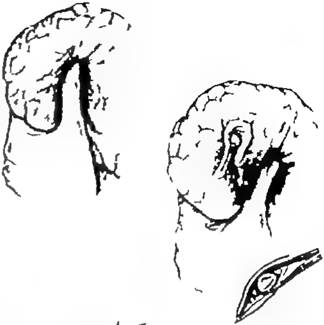
Contra indications

Foreign bodies should not be removed without exact location by pre-operative radiographs. Moreover the recently wounded lung is "wet" and further trauma may make it worse. A pulmonary haematoma usually resolves and the foreign body can be removed at leisure 3-8 weeks later The surgeon unfamiliar with lung wounds will perhaps resect contused lobes, which usually recover very well without operation

THE OPERATION

Localization of the missile

1 Local thoracotomy over the exact site of the missile a short segment of rib may be resected, or an intercostal incision made. The surgeon palpates the missile the anaesthetist keeps the lung inflated, so that the size and shape correspond to the radiograph. Localization of the missile is then easy by palpation with the hand

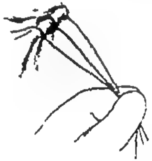


Extraction of the missile

2 Maintaining moderate inflation, the lung is incised, the incision being parallel to the vessels which radiate from the hilum. Sinus or bullet forceps follow the knife. The missile is extracted, not forgetting cloth or rib fragments, which may have gone with it. If the foreign body lies near the great vessels at the hilum, these must first be dissected so that they can be properly controlled by a catgut or tape sling before any attempt is made to extract the foreign body

Closure of the lung and chest incisions

3 The lung is sutured with interrupted thread. The chest is closed with an intercostal drain, which should go up to the apex of the pleural cavity This will allow any slight leak of air to escape under water The apical drain is removed next day if a radiograph shows full expansion of the lung



POST-OPERATIVE CARE

The post-operative management of the patient and the complications which may arise following surgical intervention are dealt with at the end of the Chapter on Injuries to the Oesophagus (page 100)

[*The illustrations for this Chapter on Surgery of Retained Missiles in the Lung were drawn by Miss Dorothy Davidson*]

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INJURIES OF THE PERICARDIUM AND HEART

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PRE-OPERATIVE

Indications

Indications for surgery are to relieve tamponade, to arrest haemorrhage, and to remove foreign bodies.

There are few opportunities to operate on wounds of the heart for many of those cases in which operative intervention is needed urgently die before such aid is possible A small wound of the pericardium and myocardium from a knife or stiletto may result in serious haemorrhage inside the pericardial sac the incision in the pericardium is so small that blood accumulates in the sac under pressure, resulting in cardiac tamponade. This will be relieved immediately by needling the pericardium, but more effectively by opening the pericardium widely The imprisoned compressed heart can then spring to life The bleeding from the myocardium can then be controlled by suture.

Foreign bodies in or near the pericardium are best removed. During World War II we saw these retained fragments cause recurrent attacks of pericarditis, until they were removed Foreign bodies in the chambers of the heart are extremely rare. They can sometimes remain without causing trouble but if technically possible they should be removed by cardiotomy It is well to remember that the danger in these cases may not be the foreign body but the damaged heart muscle A cardiotomy incision in a recently wounded heart may be much more difficult to close than the cardiotomy for valvular disease

Migrating foreign bodies

Once a metallic fragment enters a blood vessel it may move to some other part of the vascular system. For instance, a missile may enter the femoral vein through a small punctured wound in the thigh, but later call attention to itself in the lung when the patient has haemoptysis. Such intravascular missiles may also cause the scattering of secondary thrombi, so that repeated pulmonary emboli are often an indication that the missile is in a great vessel.

Blood transfusion

An essential pre-operative measure is to have adequate supplies of blood available for transfusion. It is also important in those patients with retained foreign bodies to commence treatment with antibiotics on the day before the operation.

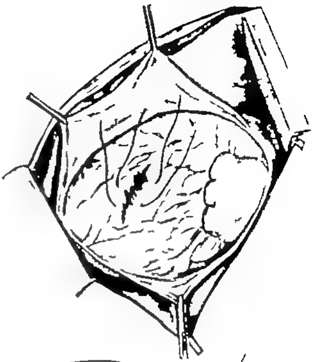
Anaesthesia and position of patient

Positive pressure anaesthesia with a cuffed endotracheal tube is used, with the patient in the normal supine position.

THE OPERATION

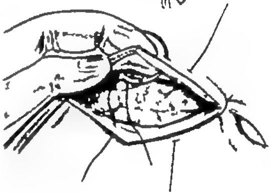
Suture of the myocardial wound

1 Usually an anterior approach through the fifth left rib or interspace the incision extends from the posterior axillary line to the sternum. The bulging tense pericardium is seen with a tiny wound spurting blood. Rapid incision of the pericardium will decompress the heart, which springs to life. The myocardial wound is sutured with interrupted thread. It is often easier to use a large curved intestinal needle by hand without a needle holder. The fingers can pass the needle quickly following the heart movements without any rigidity. Bleeding from the ventricle can be controlled by finger pressure on the firm ventricular muscle but a wound in the thin, more friable auricle needs a clamp to control it if possible. A small curved intestinal clamp might be used for the auricular appendages.



Closure of the pericardium

2 The pericardium is loosely sutured to prevent prolapse of the heart, but to allow free drainage of pericardial fluid into the pleural cavity. The pleural cavity is drained by an intercostal drainage tube.



POST-OPERATIVE CARE

The post-operative management of the patient and the complications which may arise following surgical intervention are dealt with at the end of the Chapter on Injuries to the Oesophagus (page 100).

[*The illustrations for this Chapter on Injuries of the Pericardium and Heart were drawn by Miss Dorothy Davidson.*]

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INJURIES TO THE OESOPHAGUS

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PRE-OPERATIVE

CERVICAL OESOPHAGUS

Prevention

Tears of the cervical oesophagus may be due to trauma with the oesophagoscope or gastroscope. Such tears are nearly always on the posterior wall just above the crico-pharyngeus. They occur more readily in thin frail old people, particularly those with osteo-arthritis of the cervical spine. With gentle passage of the instrument they should not occur but oesophagoscopy should be avoided, if possible in patients with severe arthritis of the spine, particularly in those cases showing osteophytes on the cervical vertebrae. If the examination is made under general anaesthesia, the anaesthetist should use a narrow intra-tracheal tube to leave the surgeon plenty of room in which to manipulate the oesophagoscope. Even so in some cases it is wise for the surgeon to choose his narrowest instrument of the Jackson type in preference to the wider Negus oesophagoscopes, which are more generally employed.

Injury may be due also to perforation by foreign bodies, either those swallowed, such as bones, or those due to enemy action.

Indications

Though tiny perforations can undoubtedly be treated conservatively by withholding food and fluids by mouth and by the use of antibiotics, all definite oesophageal tears are better repaired by operation and the cellular tissues of the retro-pharyngeal and posterior mediastinal spaces drained, if there has been contamination. If in any doubt, it is much better to operate a laceration is always found in the oesophagus in such cases, even in the absence of such classic signs as surgical emphysema. There is no longer any desperate urgency however provided that swallowing of fluids stops and that antibiotics are given immediately. A perforation of the oesophagus was once very nearly always fatal unless the mediastinum was drained this is no longer so. In the particularly worrying case in which damage has been done at endoscopy it is usually quite reasonable to adopt a conservative attitude at first. If unmistakable signs of perforation and retro-pharyngeal infection develop there is then no doubt that the neck must be opened.

THORACIC OESOPHAGUS

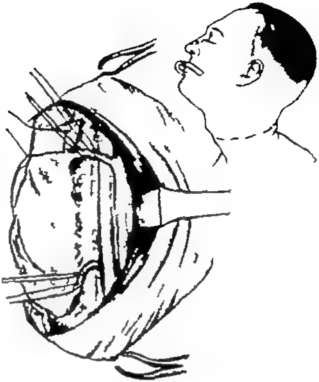
Indications

Nearly all tears or wounds of the thoracic oesophagus should be repaired, especially those at its lower end. Though wounds in the upper oesophagus may occasionally heal spontaneously when swallowing is stopped, wounds nearer the cardia may be bathed in regurgitated gastric juice which quickly prevents all healing. The severity of the symptoms in these perforations of the lower oesophagus resembles the sudden acute pain of a perforated peptic ulcer. It is quite different from the slight retro-sternal soreness that may occur after an oesophagoscopy. If there is perforation into the pleural cavity fluid will form quickly and a pneumothorax will be present. If the mediastinal pleura is not torn there will be no pneumothorax, but mediastinal emphysema and a pleural effusion will later develop.

The indication is to suture the oesophageal wound and to get the lung expanded as soon as possible. If this is done immediately the chest may be closed but if there is soiling of the pleural cavity it is usually wiser to provide temporary intercostal drainage.

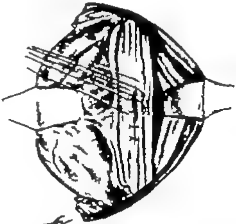
THE OPERATION

CERVICAL OESOPHAGUS



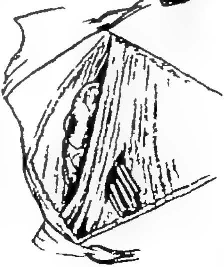
Exposure

1 Horizontal incision in a fold of the neck on the left side, similar to the exposure for thyroid ectomy but there is no need to cross the mid line. The middle thyroid vein and inferior thyroid artery are divided. The left lobe of the thyroid is then retracted to the right, rotating the trachea in a similar direction. This then exposes the cervical oesophagus. The carotid sheath is retracted gently laterally



Suture of the wound

2 The oesophagus is then exposed and the retro-pharyngeal space entered. Oedema of these fascial planes will always be present and will guide the surgeon to the perforation or localized abscess. The tear in the oesophagus is sutured with fine interrupted thread or silk.



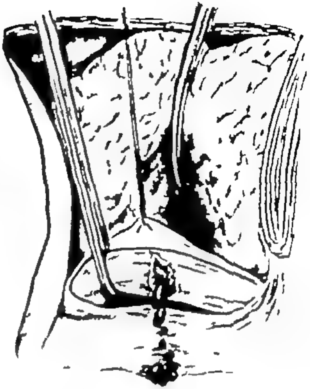
Drainage of the retro pharyngeal and retro-oesophageal space

3 The retro-pharyngeal and retro-oesophageal space is drained by a soft drainage tube which will not be firm enough to cause pressure necrosis of the carotid artery which it must cross to reach the surface. The wound is then loosely sutured.

THORACIC OESOPHAGUS

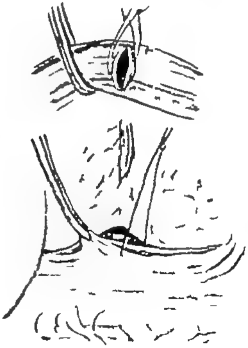
Exposure of the oesophagus

4 The chest is opened through the bed of the seventh or eighth rib. Though much of the oesophagus is more accessible through the right thorax, most instrumental perforations occur just above the cardia, which is more easily exposed from the left. It is best to choose to operate on the side in which the patient feels pain and which shows effusion or pneumothorax on the radiograph. The oesophagus is easily found after incising the mediastinal pleura.



Suture of the wound

5 The tear in the oesophagus is sutured with a single layer of interrupted thread sutures, which traverse the mucosa as well as muscle. The mediastinal pleura is loosely sutured so that there is free drainage into the pleural space. The lung is expanded and the chest is closed with intercostal drainage. If the perforation is large, a gastrostomy can be performed or better still a jejunostomy which will prevent regurgitation of food.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS IN CHEST WOUNDS

Traumatic "wet lung"

This is most common after penetrating wounds. Care must be taken to avoid over-transfusion in some patients with severe pulmonary haematoma. The airway must be kept clear by assisting the patient to cough. If this is unrewarding tracheal and bronchial suction may be necessary using a fine tube for the purpose.

Surgical emphysema

This may spread to the face and neck, to make vision almost impossible and swallowing difficult. Severe emphysema is nearly always due to a tension pneumothorax, which should be decompressed with a needle or catheter. Occasionally mediastinal surgical emphysema is so bad that a small incision is required in the jugular notch to open the superior mediastinum.

Haemothorax

This is common, due to the negative intrapleural pressure. If intercostal drainage is not done at the time of the operation, aspiration of pleural exudate may be required 1–2 days later. This is important, for early aspiration of the haemothorax accelerates complete expansion of the lung and restoration to normal function; more important still it prevents the formation of an empyema. Aspirations should be repeated till no fluid remains. A neglected haemothorax may clot, and if it is infected thoracotomy will be necessary to remove it and a decortication may then be necessary to get the lung to expand. Thorough aspiration is most important in after-care of all chest wounds.

Empyema

Infection will always occur in these wounds. Thorough excision of wounds, evacuation of haemothoraces, and the administration of antibiotics, all reduce its incidence.

Anoxia and anaemia

Though oxygen may be necessary for these patients, many of them are also anaemic. A slow transfusion of blood will improve the oxygen-carrying capacity and this is often better than continuous oxygen therapy.

Transportation of chest wounded cases

On active service, the man with a penetrating lung wound is often fit enough to be evacuated as a stretcher case in 24 hours. When infection occurs he will be less fit for moving, so that it is best to get him moved to a hospital soon after wounding. At hospital he should remain until he is safely over the acute phase of pleural infection; an empyema will have been drained if necessary before he is sent to Base Hospital.

Evacuation by air is pleasant only if the roads to the airfield are good. The air in a pneumothorax will expand by about a third of its volume for every 5 000 feet above sea level. If such cases are evacuated by air, the doctor in charge must therefore carry a syringe and needle with which he can remove air from a chest if the altitude causes dyspnoea to develop in one of his patients.

[The illustrations for this Chapter on Injuries to the Oesophagus were drawn by Miss Dorothy Davidson.]

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WOUNDS OF THE FACE AND JAWS

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GENERAL PRINCIPLES

The treatment of wounds of the face and jaws may be divided into three phases (1) first-aid and primary (2) intermediate and (3) reconstructive

The same principles cover the treatment of both gunshot wounds and injuries to the face and jaws resulting from civilian traffic and other accidents.

In this chapter the treatment of a through and through gunshot wound of the face and jaws has been considered up to the stage of late reconstructive surgery which is described in another volume.

Indications for emergency tracheotomy

In some patients an emergency tracheotomy is necessary

The indications for this in jaw wounds are (1) laryngeal spasm at induction not responding to other measures (2) jaw wounds associated with wounds of the pharynx and larynx, and some tongue wounds (3) when the nasal airway is blocked and the jaws are fixed together (4) whenever there is real doubt about adequacy of the airway and of the post-operative supervision.

Morphine and all opiates are best avoided, and indeed should only be given to patients with jaw wounds when other injuries are causing really severe pain.

Anaesthesia

If expert anaesthetic services are not available it is practicable and much safer to apply the full formal treatment of gunshot wounds of the jaws under local anaesthesia but under ordinary circumstances general anaesthesia is preferable for almost all cases. General anaesthesia comprises Pentothal induction plus muscle relaxant, pharyngeal toilet, intubation, naso-pharyngeal pack, a level of anaesthesia which keeps the patient immobile but permits rapid return of the cough reflex, removal of the tube and the pack, and a further naso-pharyngeal toilet.

Local analgesia —Xylocaine 1 or 2 per cent, with adrenaline and hyalase injected by fine bore needles is used. Local infiltration of the wound margins is the most widely used method, but this can often be supported with advantage by deliberate block of inferior dental, inferior orbital or supraorbital nerve On occasion a Gasserian ganglion block may be used. A nerve block is necessary for the manipulation of most fractures and 50–60 ml. of solution should suffice for all cases.

Oral hygiene

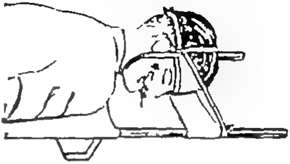
The proper care of the mouth in all jaw fractures, particularly in those with raw internal surfaces, is of the greatest possible importance in the prevention of serious infective complications, including secondary haemorrhage and in the maintenance of patients morale and avoidance of odour It is important that at the earliest possible stage the patient perform these offices for himself with toothbrush and mouthwash 2 per cent soda bicarbonate or $2\frac{1}{2}$ vol. of hydrogen peroxide are suitable mouth washes every 3 or 4 hours. When sloughs and exposed bone are present, causing excessive odour potassium permanganate can be valuable. In such cases, a dental chip syringe or Higginson s syringe can be useful.

Feeding

Most cases manage well by mouth. Major wounds, especially those involving the pharynx, are fed by indwelling Polythene naso-pharyngeal tubes. Gastrostomy is very rarely performed.

GUNSHOT WOUNDS

First aid posture of choice in transit



1 The objective is the prevention of suffocation which is the commonest cause of death. Faulty posture, that is to allow the patient to lie on his back, is very likely to cause this.

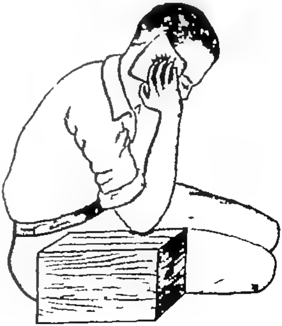
This figure shows a safe method of transport. The tongue falls forward, blood and saliva escape forward. Bandages stabilize the position of the head.

Proper posture and tongue traction will avoid the need for early tracheotomy in most cases, but if foreign bodies or bone fragments are lodged in the larynx, this may have to be carried out. Laryngotomy is to be avoided.

Alternative first aid posture in transit

2 This position also maintains the airway by the forward posture of the tongue and by permitting saliva and blood to drain out of the mouth. In this position also when the breathing is difficult or stertorous, traction on the tongue by a transfixing suture is of great value—especially when expert supervision is not available. Care must always be taken to see that the patient's head is not turned into the pillow

First aid arrest of haemorrhage



3 Even major neck vessels after division show a strong tendency to temporary spontaneous arrest, especially if pressure is applied. Pressure is applied manually by doctor or patient over a shell dressing while the patient is sat up If bleeding continues, pressure is applied above behind the angle of the jaw and below above the clavicle over the sixth cervical transverse process. If massive bleeding continues then (1) the skin edges can be closed by heavy deep temporary silk sutures (after plugging of any mucosal tear) (2) by application of Spencer Wells forceps to upper and lower extremities of depth of wound (a procedure dangerous to adjacent important structures)

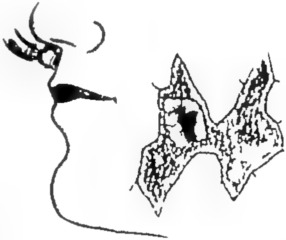
MANDIBULAR WOUND IN REGION OF LEFT ANGLE

4 There is a compound fracture with gross comminution of the mandible and teeth involvement. Detached bone fragments, many of them with sharp edges, fragments of teeth and splintered metallic foreign bodies are diffusely driven through the cheek and neck. The tracks of such wounds are often in close relation to the carotid sheath. Always beware of the gunshot wound of the jaw or neck in a patient who has a Horner's syndrome be prepared at operation for gushing haemorrhage and have arrangements for blood replacement ready

Examination and determination of the anatomical extent of the lesion

5 Examination is first by inspection when the anatomical possibilities of the wound are assessed later under anaesthesia, the wound is formally explored and the exact anatomical extent is determined and all foreign bodies removed. In this case the combined clinical and operative examination shows that the facial nerve and parotid ducts are intact, but the lower seventh molar tooth is shattered and loose. Radiography confirms that the roots of the eighth molar tooth are involved although this tooth is still firmly embedded and will be of value in the fixation.

Toilet.—A most meticulous and repeated toilet by gentle thorough lavage with a detergent is essential for all wounds, and is performed at the time of exploration. It may be combined with scrubbing brush removal of the ingrained dirt at the skin edges or with the removal of particles of dirt with needle and forceps.

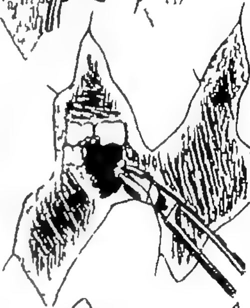


Haemostasis

6 During exploration of the wound, bleeding vessels can almost always be secured by a local approach after proper positioning of the head, neck and shoulders retraction of the wound margins by hooks or retractors, and when necessary a planned extension of the wound. Good lighting is important. In a small minority of intractable cases of haemorrhage proximal ligation of the external carotids (one or both) may be necessary In all cases careful exposure and separate clamping of vessels without neighbouring tissues is essential.

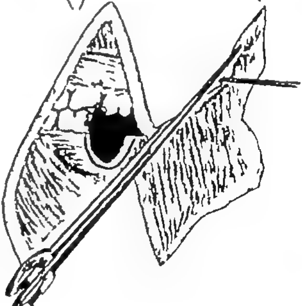
Excision of detached bone fragments

7 During exploration scattered detached bone fragments are removed. Bone nibblers then remove soiled, uneven and loose bone-ends at the fracture site. This removal is conservative and all bone with reasonable attachment which might live is left at primary operation.



Wound excision

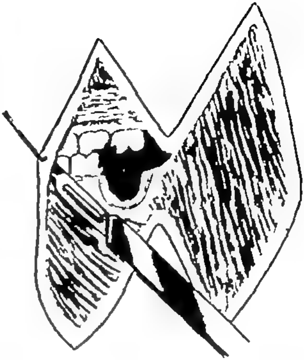
8 A minimal marginal excision, of about 1–2 mm. of skin and mucosal edges, is performed to provide non-bevelled, non-contaminated edges for accurate apposition. Deeper layers, between skin and mucosa, are excised if soiled or grossly contused or otherwise devitalized.



Undermining

9 While traction is supplied by Gillies skin hooks, skin edges are undermined by a No 15 blade for 1–6 cm to allow an exact skin edge apposition without tension or dead space If there is still tension after such undermining the closure must be by free graft or by local or distant flap Primary free graft and flap repairs generally need a later revision

Free grafts are used when the defect has an even soft-tissue vascular bed. When there is bone in the base of the defect or there has been a considerable amount of soft-tissue loss, a local rotation flap from the neck, or a distant forehead flap may be used.



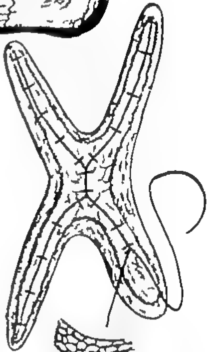
Extractions

10 The loose comminuted seventh molar is extracted but the eighth, which is firm though its roots are in a fracture line, is left at primary operation. Later extraction may be necessary but its retention is of value to the early fixation.

After extrication and removal of loose bone in the mouth, a flap of buccal mucosa may be necessary to close the mucosal defect and seal off the fracture site from seepage of saliva.

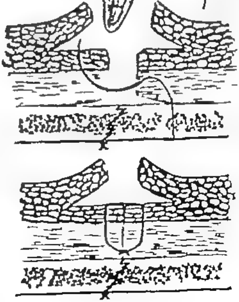
11 Fixation of jaw fragments

After impressions have been taken for later cast metal splints, primary fixation is by eyelet and direct wiring which provides temporary fixation of the jaw fragments.



12 The layered closure

Subcutaneous and mucosal layers are closed with three 0 catgut sutures (whose knots are tied on the deep surface) to provide a flat even bed under the skin closure.



13 Closure of soft tissues (subcutaneous and mucosa) above the fracture site

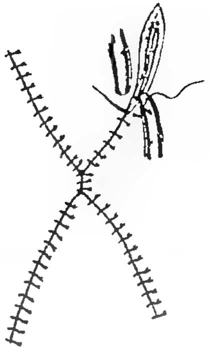
Fine catgut is employed. When the communication with the mouth cannot be given a reasonably watertight closure the fracture site must be provided with dependent drainage—through the wound or by separate incision.

Internal and external soft-tissue cover of the fracture site when possible without gross tension aids rapid union and reduces the incidence of sequestration and infective episodes.

Skin closure

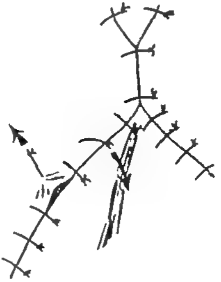
14 Most skin closures are by apposition (except when skin loss is such that the closure by apposition causes excess tension or dead space). Over an even subcutaneous bed three 0 silk sutures (on No. 16 half-curved needle) take bites of skin and fat 3–4 mm apart, and 3–4 mm. in depth and width. Each suture is inserted at right angles to the skin edge to aid exact edge apposition.

Dependent drainage through the wound or by separate inferior incision is given to fracture sites still in communication with the mouth.



Removal of sutures

15 Fine silk sutures are used for the skin wound and are removed early—between the third and fifth days. During removal of these sutures the head of the patient is positioned and the elbows of the surgeon are supported on either side of it on the table. The suture is lifted by the knot, cut beneath it and drawn out across (not away from) the wound. The wound is left free from dressings after removal of sutures. The correct and incorrect methods of removing a suture are shown.



Definitive fixation of jaw fragments

16 Cast metal splints provide the most secure and rigid definitive fixation of comminuted jaw fractures. They are generally applied after the first few days, or (as in the case when the root of a retained tooth is involved in the fracture line) when the course of the fracture in relation to that involved root is clear (generally in about 2 weeks)

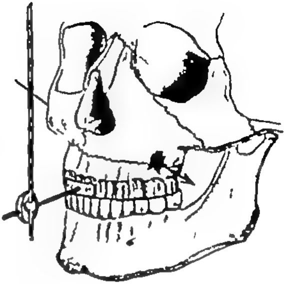
GUNSHOT WOUND OF MAXILLAE INVOLVING ANTRA

17 These wounds have a higher mortality than mandibular wounds. Associated brain and eye damage is commoner as are early and late haemorrhage and respiratory complications.

The common displacement of the lower alveolar fragment is to cause some degree of gagging in the incisor region due to downward displacement in the molar region.

The care of the soft tissues in wounds less than 48 hours old is as in mandibular wounds—toilet, excision, layer closure without tension, by approximation after undermining for most cases, by flap or free graft where skin loss is great.

Repeated major epistaxis may need formal exposure and ligation of the anterior ethmoidal artery



Fixation of maxillary wound

18 After thorough toilet of soft and bony tissues in the wound track plus skin-edge excision and fairly radical removal of loose bone fragments, fixation after reduction by manipulation is by cast metal splints supported by a connecting rod to a P O P head cap This fixation is simply cranio-maxillary (that is, the lower jaw is free) unless the mandible is also fractured, when it is combined with intermaxillary fixation. If the reduction of the

19 gagging is difficult, upward traction on the molar region by cheek wires may be necessary There should be a wire bracket on the P O P to which the rod is attached. If intermaxillary fixation is used in the presence of nasal obstruction a tracheotomy is necessary

The removal of bone fragments in maxillary wounds is more radical at primary operation than is the case with bone fragments of the mandible. This is to prevent later antral infection and also because union of the maxillary fracture is seldom delayed after relatively radical excision of comminuted fragments. The removal is particularly radical in the medial wall of the antrum, to provide a natural antrostomy but is conservative as regards floor of orbit and alveolar fragments. A formal antrostomy is not regarded as a necessary prophylactic measure at primary operation. It is carried out if soiling is gross or infection already present.

[*The illustrations for this Chapter on Wounds of the Face and Jaws were drawn by Mr F Price*]

PART III

ABDOMEN

PART III ABDOMEN

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SURGERY OF ACCESS TO THE ABDOMEN

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TYPES OF INCISION

Many incisions have been used for access to the abdominal viscera. Time has simplified the great majority down to about a dozen separate incisions.

Vertical incisions

Midline.—This incision is made through the linea alba above or below the umbilicus or skirting round it. It provides good access to all the abdominal viscera and easily can be extended in either direction. The linea alba, particularly above the umbilicus, provides a strong layer and the incision heals soundly.

Paramedian.—This may be made about 1 inch to the right or left of the midline above or below the umbilicus and provides almost as good access as a midline incision. It takes longer to make as the anterior rectus sheath has to be dissected off the muscle which is then retracted outwards in order to make a longitudinal incision through the centre of the posterior rectus sheath.

Rectus split.—Some surgeons prefer to make a vertical incision 1 inch or so from the midline cutting through skin, rectus sheaths and rectus muscle in the same line. This incision is easy to make but the muscle lying medial to the incision is deprived of its nerve supply and subsequently atrophies.

Battle's pararectal incision.—This incision was originally made in the right lower quadrant. The skin and anterior rectus sheath are cut vertically a little to the outer side of the middle of the rectus, which is then gently freed and retracted medially. The posterior sheath and peritoneum are then opened. This incision has become unpopular in some quarters because it is difficult to extend without damage to the nerve supply of the rectus muscle and because the deep epigastric vessels are liable to damage.

Oblique incisions

Kocher's.—As now practised, this consists of an oblique epigastric incision a little below and parallel to the costal margin, dividing the rectus abdominis muscle and its anterior and posterior sheaths in the line of the incision.

Grid-iron.—This is an oblique incision usually in the right lower quadrant (sometimes in the left), centred one-third of the way from the ilium to the umbilicus. Through this incision the external oblique, internal oblique and transversus muscles are successively split in the line of their fibres and the peritoneum opened.

Rutherford-Morison.—This is an oblique incision made in the lower quadrant of the abdomen along the line from symphysis pubis to above the iliac crest cutting through all the muscle layers in the same line. Some surgeons prefer to gain similar exposure by a muscle-splitting incision which combines the advantages of a Rutherford-Morison with those of a grid-iron incision.

Transverse incisions

Epigastric.—An approximately transverse incision in the epigastrium cutting through the rectus and other abdominal muscles in the line of the incision has been found useful for access to the epigastric viscera, and to heal well.

Umbilical.—A similar muscle-cutting incision may be made to either side of the umbilicus or right across, and at this level is not so restricted by the costal margin.

Pfannenstiel.—This is a transverse suprapubic incision dividing the rectus sheath in the same line and retracting the rectus muscles to each side.

Transverse pararectal.—This modification of the Battle's incision divides the lateral border of the anterior rectus sheath and the linea semi-lunaris transversely. The rectus muscle is then retracted medially and the posterior rectus sheath and peritoneum are divided in the line of the incision.

Thoraco-abdominal

The abdominal portions of these are usually transverse or oblique muscle-cutting incisions which have been extended laterally through the costal margin.

Compound incisions

It is often convenient and satisfactory to combine two standard incisions where it is necessary to get better exposure. For example, a transverse incision joined to a vertical median one, or *vice versa*. Some surgeons favour oblique rectus-cutting incisions across the epigastrium.

CHOICE OF INCISION

It is generally convenient to confine oneself to a few incisions and develop a standard technique. This helps one's assistants and theatre staff, though there will be occasions when a different incision is expedient.

Of the vertical incisions, the midline epigastric is quick and easy to make and close, provides good access for the upper abdominal viscera—notably for the upper end of the stomach—and is a good standard incision for gastrectomy.

Below the umbilicus a paramedian incision is preferable as the linea alba is tenuous and subject to stretching, particularly during pregnancy. Vertical incisions have, however, the disadvantage that they are probably more painful in the immediate post-operative period and consequently interfere with coughing. If abdominal distension should occur they are liable to disruption and in the author's opinion they are more uncomfortable and more liable to early separation and later weakness than either oblique or transverse incisions; they should therefore be used only when the necessary access cannot be satisfactorily obtained by another type of incision.

For this reason Kocher's incision is preferred by some for access to the biliary apparatus and on the left, to the spleen.

A grid-iron incision is likewise preferable to a lower paramedian for appendicectomy and a Rutherford-Morison or transverse incision for operation on the right or left colon respectively.

However, these general rules are a matter of personal preference and many surgeons would not support them.

SUTURE MATERIALS FOR CLOSING THE ABDOMINAL WALL

These must be strong, easily sterilized without deterioration, non-irritant, non-capillary and of large enough calibre not to cut through the tissues.

The two materials which best fulfil these criteria at present are (a) Stainless steel wire, which has the disadvantage of being difficult to use without kinking; (b) Monofilament nylon, which is difficult to knot and not infrequently is subsequently discharged through a sinus or has to be removed.

Catgut is among other materials in common use This is relatively very expensive because of the elaborate manufacturing processes It has the advantage that it is eventually completely absorbed by the tissues and it is commonly used for closing the peritoneum It has the great disadvantage that after insertion it swells and becomes very slippery and the knots have a tendency to become untied. Catgut with sufficient strength for the chief layers of the abdominal wall has to be of stout calibre and an adequate knot is bulky and will often cause a palpable lump and foreign body reaction if placed near the skin

In the author's opinion with the possible exception of paediatric surgery and operations on septic conditions such as appendicitis, catgut need never be used for closing the aponeurotic muscular layers of the abdominal wall.

Cotton and linen thread and various forms of silk are commonly used for closing abdominal incisions. They are cheap easy to handle and easy to sterilize they knot securely and the ends can be cut short, but they have the outstanding drawback that they are capillary and liable to infection and in this event will cause stitch sinuses which will persist until the offending suture is removed. For this reason continuous sutures of these materials should never be used for closing abdominal incisions and even interrupted sutures are undesirable near the skin. Wire or monofilament nylon is preferred.

METHODS OF CLOSURE

Peritoneum

It is usual to close the peritoneum with a layer of continuous fine catgut inserted with a round bodied needle. In the case of the grid-iron incision a purse-string stitch leaves a minimal scar and presumably less chance of adhesions forming Where possible the peritoneal suture line should evert the peritoneal edges for the same reason.

Closure of the peritoneum used to be considered a very important step before the advent of muscle relaxants as it would then keep the viscera inside while the main layers of the incision were being sutured. Peritoneum has a very strong natural tendency to close spontaneously and there is some evidence that a peritoneal suture is unnecessary In closing an upper paramedian incision peritoneum and posterior rectus sheath are usually closed as one layer

Aponeurosis

The texture of this layer will vary according to the incision used. In the upper midline incision it consists of the stout interlacing fibres of the linea alba, whereas in paramedian incisions anterior and posterior rectus sheath both consist of relatively thin layers of transversely running aponeurotic fibres which are not so suitable for secure suturing

Thus in a midline incision a single continuous suture inserted with a triangular or trocar-pointed needle and sutured with monofilament nylon or 32 gauge stainless steel wire is adequate With weaker layers and a risk of stitches cutting out, it may be preferable to use mattress stitches in some cases.

Muscle

Usually it is unnecessary to suture muscle fibres. Where these have been split as in the grid-iron incision one or two approximating stitches tied loosely so as not to strangulate the muscle fibres may serve to close the dead space.

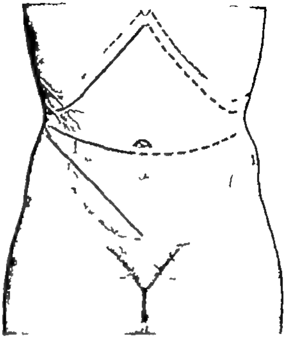
Where muscle fibres have been cut across as with the rectus abdominus, they may not be sutured, but the anterior rectus sheath is accurately closed and provides a strong effective layer

GENERAL PRINCIPLES

Transverse incisions

1 Horizontal or transverse incisions in the skin and through the musculature generally heal more comfortably than vertical especially if there is distension.

In this diagram the transverse and oblique incisions may be extended laterally the Kocher's incision must not be, as paralysis of the abdominal muscles may result through division of the segmental nerves.

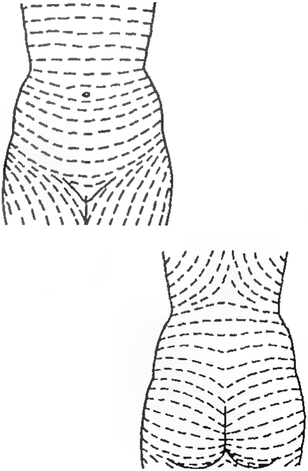


Langer's lines

2 Where otherwise convenient, a skin incision should follow the direction of Langer's lines, because a better skin scar results with less tendency to keloid formation and healing is more certain. This means that oblique or transverse incisions should as regards skin healing be preferred to vertical incision.

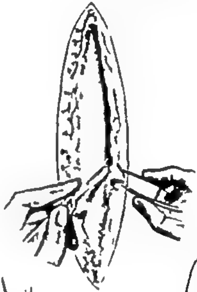
Composite and oblique incisions are sometimes necessary to gain exposure of an unexpected finding

Some surgeons prefer slantwise oblique incisions in upper abdominal exposure.



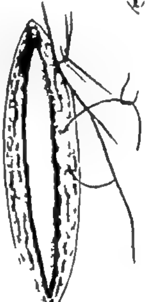
Midline epigastric incision

3 The skin incision is made exactly in the midline from the xiphoid to the umbilicus. It may be extended upwards by excising the xiphoid cartilage or even further by splitting the sternum as far as the fourth intercostal space and downwards by moving to one side or the other of the umbilicus and extending the incision as a paramedian into the rectus sheath.



Deepening the incision

4 The incision is then deepened with a knife down to the linea alba throughout its length and the fat is carefully dissected off the front of this layer for ¼-inch at each side. This is done to facilitate accurate closure of the linea alba without fat interposition. Haemostasis is then achieved. A good method is for the surgeon with fine artery forceps and a swab to pick up the point only of each bleeding vessel while an assistant touches the handle of the forceps with a diathermy electrode.

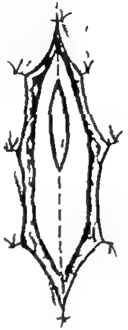


Securing skin covers

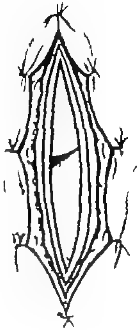
5 Skin covers are then secured in position by
6 means of a thread stitch taking a generous bite through the subcutaneous fat and a wide bite of the towel edge.

Incising the linea alba

7 The linea alba is next incised throughout the length of the incision. Care must be taken not to cut through the peritoneum into the underlying viscera, and if the peritoneum should be opened two fingers may be inserted into the abdomen beneath the line of the incision to protect any subjacent organs and to identify those which may be found adherent to the abdominal wall. A few small vessels commonly cross the midline in the extra-peritoneal fat these should be touched with diathermy



8 It should be mentioned that frequently a part of the incision opens the rectus sheath, having deviated from the exact midline. This does not affect either the closing of the incision or its subsequent strength.

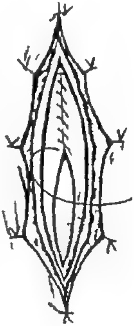


Closing the abdomen

For this procedure it is desirable to have good muscular relaxation and quiet breathing

The peritoneum

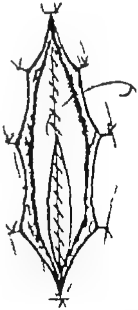
9 It is usual to close the peritoneum using a fine continuous catgut stitch with a round bodied needle.



Aponeurosis

10 This may be closed by a continuous stainless steel wire or monofilament nylon suture, taking approximately ½-inch bite of the linea alba at each side at approximately ½-inch intervals. The peritoneum and extra-peritoneal tissues should not be included in this layer as the strength of the scar depends on accurate apposition of the aponeurosis without interposition of extraneous tissues.

Where the rectus sheath has been opened the stitch should include the anterior and posterior sheaths. If the tissues are of poor quality and *there is doubt about the security of the suture-*line, it may occasionally be desirable to insert a few additional interrupted sutures.



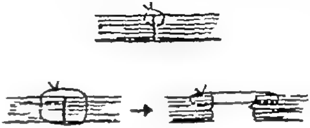
Subcutaneous tissues

The skin covers are now removed by cutting the thread sutures. There is no need to suture the subcutaneous tissues whether they be fat or thin

Skin

11 There are a great many ways of suturing the skin, all ensuring the necessary principle that the skin edges must be firmly and accurately pressed together until they are healed Casual closure of the skin is certain to lead to overlapping of the edges leading in some cases to sepsis, delayed healing and troublesome scars. Interrupted vertical mattress stitches of serum proof non-capillary braided silk are simple and effective A similar stitch may be inserted using continuous silk some surgeons prefer metal clips and others use a continuous subcuticular stout monofilament nylon stitch which is quick and easy to insert, painless to remove and devoid of stitch marks and suture sepsis

Where drainage of the abdomen is necessary the drain is best brought out through a separate small stab incision Occasionally uncontrollable subcutaneous oozing demands drainage of the subcutaneous layer for 24 hours. This drain may be brought out through the lower end of the wound.



Deep tension sutures

By this term is meant the use of a series of wide bite sutures passing through the skin and the aponeurosis, which are tied over a substantial pad at the conclusion of the operation.

PARTICULAR INCISIONS

Kocher's incision

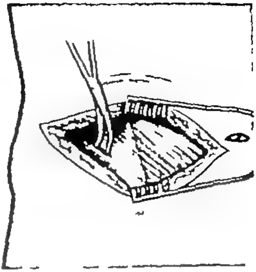
12 The modern version of this is made through a skin incision 1 inch below the costal margin and parallel to it, deepened in the same direction through the rectus abdominus and its anterior and posterior sheaths. One or more segmental nerves may be divided with the posterior sheath. A number of branches of the superior epigastric vessels will be encountered in the rectus muscle.

The incision may be extended symmetrically across to the left providing generous exposure of the epigastric viscera, but it must not be extended laterally or paralytic incisional hernia may result. This incision gives good access to the biliary tract and on the left to the spleen. It may be drained through its outer extremity

Transverse umbilical

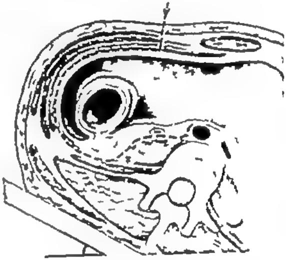
13 The skin incision is approximately horizontal at the umbilical level. It is deepened through the muscle layers in the same line. It is rarely necessary to divide the rectus abdominis this can be retracted medially and the posterior *sheath divided in the line of the incision.*

If an extra-peritoneal exposure is sought, it will be more easily found 1–2 inches lateral to the rectus, as medially the peritoneum is adherent to the posterior rectus sheath at this level.



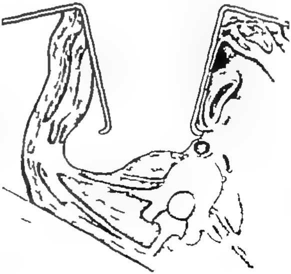
To reach ureter

14 In order to reach the ureter or sympathetic chain it is necessary to break through a layer of fascia at the outer border of the quadratus lumborum. The dotted line shows the direction of this dissection.



The sympathetic chain

15 To display the sympathetic chain good muscular relaxation a 30-degree tilt to the opposite side and deep retractors are necessary *Uses*—This incision is used extra-peritoneally for lumbar sympathectomy and uretero-lithotomy Transperitoneally it is useful for operations on the colon. It heals well without discomfort or disability



Rutherford Morison

16 The skin incision runs from the top of the symphysis pubis to a point about 1 inch above the iliac crest and may be extended laterally as necessary.

The external oblique and the conjoined tendon are successively divided in the line of the incision. The deep epigastric vessels are identified and usually divided between ligatures. The transversalis fascia and peritoneum are then opened in the line of the incision. The incision is closed in layers and may be drained through whichever end gives better drainage.

Uses.—On the left this incision is useful for hemi-colectomy, anterior resection and abdomino-perineal excision and on the right is used for operations on the caecum and ascending colon. It may also be used for extra-peritoneal approach to the lower ureter on either side.

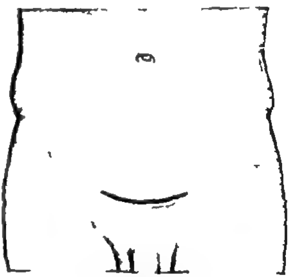
This incision heals well with little discomfort or disability.

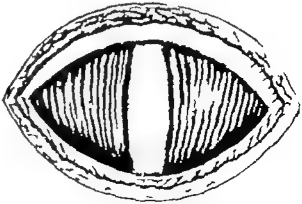
Pfannenstiel's incision

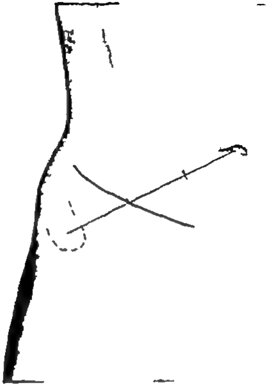
17 The skin incision is made parallel to the suprapubic skin crease below the hair line. The anterior rectus sheath is divided in the same direction and dissected free upwards and downwards in the midline as far as necessary.

18 The rectus muscles are then retracted to each side after separation of the pyramidalis muscles. The incision is closed by suturing the anterior rectus sheath of the skin.

Uses.—This incision can be used for operations on the bladder, prostate and other pelvic viscera.







Grid-iron incision

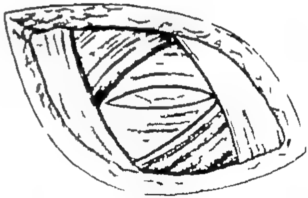
19 The skin incision is made parallel to the transverse skin creases of the abdominal wall, its centre being about one-third of the way from the anterior superior iliac spine to the umbilicus.

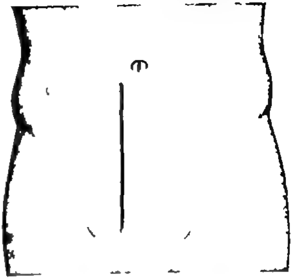
Division of muscle layers

20 Through this incision the external oblique, internal oblique, transversus transversalis fascia and peritoneum are successively split in the line of their fibres and retracted. Care should be taken to avoid injury to the appropriate segmental nerve which passes across the wound.

The wound is closed by approximating each layer but in septic cases it may be drained through its centre and left completely open and in these circumstances may heal almost as well as if it had been sutured.

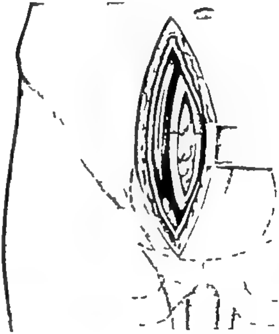
Uses—This is the most usual incision for appendicectomy It may be extended in either direction, converting it to a Rutherford-Morison and thus providing good access to the pelvis or sub-hepatic region if necessary In septic cases it is undesirable to make muscle cutting extensions as the incision may not heal soundly





Lower paramedian incision

21 The skin incision runs from the symphysis to the level of the umbilicus or above It may be made in the midline or a little to one side.

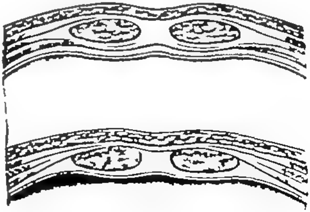


Deepening the incision

22 The fat is dissected off the external oblique, which is incised vertically about 1 inch to one side of the midline. The rectus muscle is then retracted laterally and the transversalis fascia and peritoneum opened in the line of the incision.

In the upper part of the incision the posterior rectus sheath is also incised.

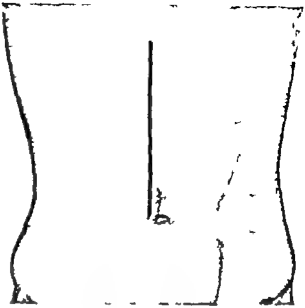
Uses.—This is used chiefly for operations on the pelvic viscera and *sometimes* for appendicectomy



Differences in epigastric and hypogastric linea alba

23 The difference is shown diagrammatically between the stout epigastric linea alba and the thin attenuated hypogastric one. This is the anatomical basis for recommending a midline incision in the epigastrium and a paramedian below the umbilicus

In some patients a very extensive exposure of the abdomen is required and then a full length right or left paramedian incision extending from the costal *margin almost to the inguinal* ligament may be used. It is probably wise when closing an extensive vertical incision of this type to insert a number of deep tension sutures in addition to the more usual closure in layers.



Upper paramedian incision

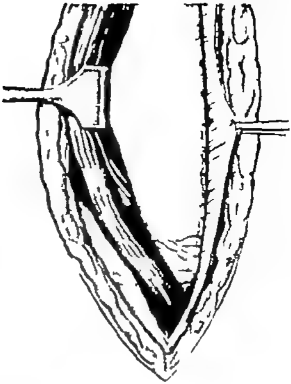
24 The skin is incised vertically a little to one side of the midline. The anterior rectus sheath is cleaned and exposed. It is then incised longitudinally over the rectus and the medial part dissected free with a knife. Diathermy is used to arrest bleeding from the muscle and sheath.

Dissection of the tendinous intersections

25 The tendinous intersections are adherent to and blended with the anterior rectus sheath and medially with the inner edge of the rectus sheath and to a less extent on to its posterior aspect. Sharp dissection frees these and each intersection contains one or more blood vessels passing from the muscle to the sheath These may be either coagulated or tied.

Retraction of the rectus

26 The rectus muscle may then be retracted laterally and the transversely running fibres of the posterior rectus sheath cut in the line of the incision. It is important not to dissect too far laterally on the posterior surface of the rectus muscle because of the risk of damaging the epigastric vessels



Possibility of dehiscence

27 The apparent additional strength of having the rectus muscle intervening between the anterior and posterior sheaths is largely offset by the fact that the fibres run transversely in both these layers and it is becoming gradually realized that a high proportion of cases of burst abdomen occur through this incision. The upper paramedian incision is both more tedious to make and close, and less secure than the upper midline incision.

Closure.—The peritoneum and posterior rectus sheath are closed together with continuous or interrupted stitches and the anterior rectus sheath likewise.

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EXPLORATION OF ABDOMEN ACUTE

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PRE-OPERATIVE

Indications

Where an exact diagnosis cannot be made, and yet because of acute signs and symptoms it is considered unsafe to temporize

Where the diagnosis is doubtful, thus in women, acute appendicitis or acute salpingitis. Many conditions will be established only on exploration, such as acute pancreatitis, mesenteric adenitis, haemoperitoneum, gall-stone ileus, lesser sac perforation. Exploration without a diagnosis should rarely be necessary and it is only in cases where the signs and symptoms are markedly atypical that one will have to resort to it. Occasionally no abnormality will be found in the abdomen and the cause of the symptoms will generally be found above the diaphragm.

All cases of penetrating abdominal wounds which can be made fit for operation.

Special contra-indications

In advanced disease of the cardiovascular pulmonary or other systems one will have to consider whether the operation or the condition for which operation is being advised is the more lethal. If the former then operation is contra-indicated

Pre-operative preparation

Ensure that bladder and rectum are empty A Ryle's tube should be passed into the stomach, and the contents of the stomach aspirated. The tube will be left in position. Intravenous infusion may be necessary to correct the fluid or electrolyte abnormalities, especially where there has been severe fluid loss by vomiting or diarrhoea. Blood transfusion may be required before or during operation

Anaesthesia

Routine general anaesthesia is usually satisfactory—though in some cases because of poor general condition it will be necessary to carry out the operation with local infiltration only

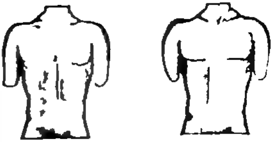
Exploration of peritoneal cavity

On opening the peritoneum a careful note should be made of the appearance and contents of the general peritoneal cavity The diagnosis may be immediately obvious, but more often it will only give an indication of the nature of the emergency and of its situation in the abdomen.

Pus

In the presence of thick offensive pus, the parietes should be gently elevated in order to try and obtain some idea of the site and nature of the lesion. This manoeuvre may fail to give any useful information in which case the left hand should be slipped into the right iliac fossa to examine the appendix which is most likely to be the cause of the trouble. If this is normal, then in the female the hand should be carried on into the pelvis and the tubes and the ovaries palpated. Failing to find any lesion here the hand is carried across the pelvis to the sigmoid colon which is palpated for the presence of diverticulitis or a carcinoma. The absence of a lesion here will lead one to explore the whole of the large bowel round to the caecum The exploration of the upper abdomen should be carried out by the right hand, the stomach, duodenum and gall bladder being carefully palpated. The whole of the small intestine should also be searched

THE OPERATION

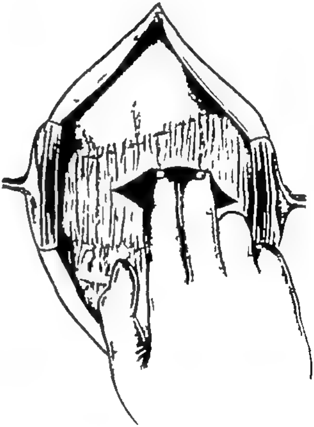


The incision

1 The quadrant of the abdomen must be assessed. For the upper abdomen a mid-line epigastric or a paramedian incision is used. An extension at right angles to this incision through the rectus abdominis will give better exposure to a ruptured spleen on the left or a ruptured liver on the right.

A right or left lower paramedian incision is best for the iliac fossae.

One should not hesitate to enlarge the incision to get adequate exposure. In some cases it may be more beneficial to make a new selective incision after the diagnosis has been made. In this type of surgery good exposure is probably the most important single factor for success.



Further exploration of peritoneum

2 Following a general search of the peritoneal cavity (as mentioned on page 18) the more unlikely sites should be explored, such as the lesser sac which is opened by dividing the gastro-colic omentum, the subphrenic spaces and the posterior abdominal wall.

Rare causes of peritonitis due to pneumococci and tubercle bacilli are suggested respectively by the odourless greenish pus in the female peritoneum, and the watery pus with a thickened gelatinous peritoneum and visible tubercles.

Blood

In the female the most likely cause of blood in the peritoneum is a ruptured ectopic gestation (*see* Part XIII) Immediately on opening the peritoneum and seeing blood, the left hand should be put down into the pelvis, the site of the lesion ascertained, and digital pressure applied while the blood is sucked out. When this has been done it is possible to see where to apply a clamp, using the right hand. Once the bleeding has been stopped, the patient's condition immediately improves and a careful assessment of the situation is made and the appropriate measures are taken.

The spleen

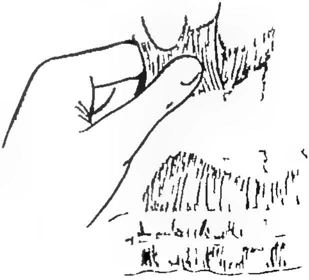
3 In the male and the female once an ectopic gestation has been excluded, the most likely sites for the bleeding are the spleen and liver so they are immediately explored. If the spleen is bleeding profusely the pedicle should be gripped with the left hand while, with the right hand and the aid of the assistant, the organ is delivered into the wound so that clamps can be applied to the pedicle and the bleeding arrested. It is then removed in the usual way

The liver

4 Bleeding from the liver may be diminished by compressing the hepatic artery and portal vein as they run in the edge of the lesser omentum. This is done most satisfactorily by inserting the index finger of the left hand through the foramen of Winslow so that the artery and vein may be gripped between the finger and thumb

If there is no bleeding from any of these sites, then the kidneys and intestines should be inspected, particular care being taken to examine the roots of the mesenteries which may be torn.

A small amount of blood mixed with bile or faecal stained fluid suggests an injury of the intestines. In penetrating wounds there may be multiple injuries, so it is important to ascertain the full extent of the damage, as this will determine the treatment which is to be adopted.

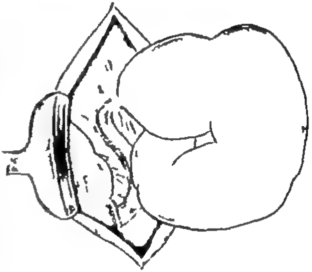


Thin watery fluid

5 This may be combined with a puff of gas as the peritoneum is opened and usually is indicative of a perforated gastric or duodenal ulcer Immediately the duodenum should be palpated and inspected and usually an ulcer can be found on the wall of the first part If there is no ulcer there the stomach should be palpated and inspected and finally the gastro-colic omentum may have to be divided in the search for a perforation of the posterior aspect of the stomach If none of these sites shows the cause of the trouble then the rest of the abdomen should be explored (*see also* page 16)

Distended coils of intestine

6 The right iliac fossa must first of all be explored to ascertain whether or not the caecum is distended. If the caecum is normal a search should be made for a collapsed loop of small intestine and this is delivered into the wound and followed up until the site of the obstruction is found If the caecum is distended then the colon should be followed round until the site of the obstruction is found which is most likely to be in the sigmoid loop situated in the left iliac fossa. While it is advisable to try and avoid exteriorizing distended loops of intestine it is better to quickly eviscerate the patient and find the cause of the obstruction than to carry out a prolonged and rather ineffectual search with the intestines still in the abdomen



POST-OPERATIVE CARE AND COMPLICATIONS

Acute dilatation of stomach is prevented by aspiration through a Ryle s tube and keeping it empty When the stomach empties itself naturally the aspirations will become insignificant in amount and clear in texture.

Paralytic ileus is specially liable to follow an operation in which there has been excessive handling of the intestine or if it has been exposed outside the abdominal cavity for a prolonged period. Gastric suction and intravenous fluid therapy with nothing by mouth will rest the intestine and allow it to recover The return of audible peristalsis will indicate that this has taken place

As in all emergency operations chest complications are more liable to occur Deep breathing and coughing exercises are carried out regularly If an area of collapse occurs the obstructing plug of mucus can be aspirated *via* a bronchoscope

[*The illustrations for this Chapter on Exploration of Abdomen Acute were drawn by Mr F Price from originals by Mr George A. Smith.*]

EXPLORATION OF ABDOMEN NON-ACUTE

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PRE-OPERATIVE

Indications

In obstructive jaundice where the causative factor cannot be ascertained.

Haemorrhage from the colon where the proctoscope, sigmoidoscope and barium enema x-ray examination show no pathology

In cases of new growth exploration may be carried out to confirm inoperability—that is where there is liver enlargement or ascites or if the tumour is fixed on clinical examination. At the other end of the scale exploration may also be carried out to confirm operability for example, prior to perineo-abdominal excision of rectum.

Again the abdomen may be explored to exclude the presence of a new growth.

In undiagnosable cysts and tumours, ascites liver enlargement.

Persistent pain, the cause of which cannot be found after full investigation and which appears to be arising from an intra abdominal lesion

Pre-operative preparation

The intestinal tract should be as empty as possible this is ensured by giving a low residue diet for 48 hours beforehand and a rectal wash-out on the evening prior to operation. A Ryle's tube will be passed to evacuate the stomach contents and the bladder should also be emptied after the pre-medication injection has been given.

Special preparation in cases of jaundice and for bowel operations is described under those headings. All the relevant investigations will be carried out, so that the operator is in possession of all information at the time of the operation that is likely to be of value to him. An x-ray plate should, in some cases, be placed under the patient, so that if needed a film can be taken during the operation without disturbing the patient or the sterile operation field. Where thought necessary arrangements should be made for frozen section pathology to be carried out.

It is important that the surgeon should have the permission of the patient to carry out any procedure which may be found necessary after the abdomen has been opened.

Anaesthesia

Routine general anaesthesia with or without an endotracheal tube is satisfactory Adequate relaxants allow better exposure and make for easier closing of the abdomen.

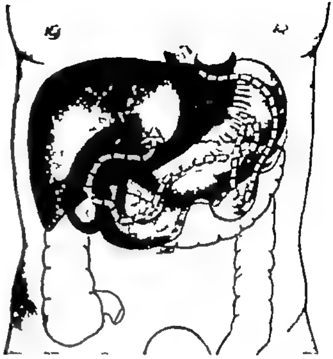
Position of patient

A sand-bag or pneumatic bag under the lower chest may make the gall bladder and bile ducts more accessible, though some surgeons dislike the use of this. Head down tilt or lateral tilt in either direction will free the pelvis or the flanks of small intestine.

THE OPERATION

General exploration

1 A general exploration should be carried out as follows. The moistened gloved right hand is inserted into the abdomen to palpate the lower end of the oesophagus and the fundus of the stomach. From here the hand comes down to palpate the left kidney and then the spleen. The tail of the pancreas can be felt in the region of the hilum of the spleen and then the hand is brought across to the right side of the abdomen palpating the body and the head of the pancreas on the way. From the head of the pancreas the hand slides over the duodenum to feel the right kidney. It is then carried upwards over the upper surface of the liver which is carefully palpated for the presence of secondary deposits, cirrhosis or abscesses. The gall bladder is gently squeezed and an attempt made to empty it. The presence or absence of stones is noted. The index finger is inserted through the foramen of Winslow and bile ducts palpated between it and the thumb.



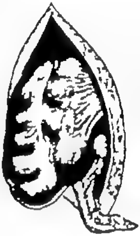
Stomach pylorus jejunum colon

2 The next part of the exploration is carried out under direct vision. The body and pyloric end of the stomach are inspected and palpated, any thickening or scarring of the wall is noted and the patency of the pylorus is assessed. In the case of a neoplasm of the stomach particular attention is paid to the sub-pyloric group of glands. The gastro-colic omentum is next divided and the back of the stomach is examined. While the lesser sac is open a better examination of the pancreas can be carried out. The jejunum is picked up at the duodeno-jejunal junction and the small intestine is followed down to the caecum. Particular care is taken not to overlook any enlarged lymph nodes at the root of the mesentery.

The colon should be followed round from the caecum to the rectum. Apart from the hepatic and splenic flexures, most of it can be examined by direct inspection.

Duodenum

3 Complete examination of the duodenum can only be done after it has been mobilized by division of the peritoneum along its outer border



Caecum

4 The caecum should be examined and it is usually possible to deliver it into the wound the condition of the appendix should be noted.

Polyp of the colon

5 The area of attachment of the pedicle of a polyp inside the colon may be discovered by the dimpling which is caused by applying traction to the polyp in one or other direction.

Uterus and ovaries

Exploration of the pelvis is facilitated by putting the patient in a steep Trendelenburg position and by the operator moving round to the left side of the patient. The uterus and ovaries and the broad ligament are inspected and palpated.

Posterior abdominal wall

Finally before closing the abdomen the posterior abdominal wall should be palpated with a view to ascertaining whether there are any enlarged retroperitoneal lymph nodes present or if there is a tumour arising from behind the peritoneum

[The illustrations for this Chapter on Exploration of Abdomen Non-acute were drawn by Mr F Price from originals by Mr George A. Smith.]

SPECIMEN ANASTOMOSIS OF HOLLOW VISCERA

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GENERAL PRINCIPLES

In British practice catgut is used more commonly than unabsorbable materials, and a continuous suture is employed more often than interrupted stitches. Interrupted stitches are used when maximum security is desired or where the structure of the viscus is unreliable.

The sero-muscular suture, whether the stitching be continuous or interrupted, is usually inserted at right angles to the line of anastomosis. A continuous sero-muscular suture (the running mattress or Cushing) is used for the first layer when the loops to be joined are lying too close together to allow stitching at right angles to them. The Cushing can be inserted loosely and pulled tight when the all-coats layer is complete

The posterior layer of the all-coats suture cannot but be inverting because the coats are already inverted. A simple running over and-over stitch is generally used. The anterior layer can also be sewn with the over and-over stitch but the result is an untidy suture line with the mucous membrane everted most of the way It can be inverted in several ways, the most common inverting stitches being the Connell and the Tyrrell Gray The Connell or loop-on-the-mucosa stitch inverts, but it is not entirely haemostatic. The Tyrrell Gray is merely an over-and-over stitch, which is pulled each time it comes out on the mucosa, the suture line being pressed with the finger or a swab at the same time it is haemostatic. Interrupted haemostatic sutures can be made inverting in the return layer if they are pulled and tied on the mucosal surface One or two Connell sutures may be needed to invert the last ½-inch of the inner layer

In making an anastomosis in any part of the alimentary canal, the surgeon brings together those parts he wishes to unite in such a way that their lumina are continuous, and the tissues on which repair depends are in apposition The mucous membranes lining the alimentary canal do not unite quickly for they are secreting surfaces. Repair is a function of mesoblastic tissues, particularly of fibroblasts, and union takes place between the mesoblastic layers, the peritoneum the muscle coats and the submucous coats. The basis of anastomosis is therefore inversion of the suture line, so that the cut edges of mucous membrane are turned in towards the lumen and the outer coats are apposed to each other in a broad flange. Sutures play a temporary part only holding the edges in the required position till they unite.

The anastomosis is in nearly all cases performed by two layers of suture.

The inner suture or all-coats suture is the key layer upon which the security of the anastomosis depends, because it traverses all the layers of the wall of that viscus and partakes of whatever strength they possess. It is also called the haemostatic suture because, if spaced closely enough, it must control any blood vessels in the muscular or submucous coats.

The outer or sero-muscular suture is an inverting suture whose object is to reinforce the all-coats suture line to invert it more fully and to secure broader apposition of the outer coats of the viscera being anastomosed. The sero-muscular suture, also called the Lembert or Czerny-Lembert suture, passes in a bight through the serous and muscular coats, picking up the submucous coat on which the security of its hold depends in the deepest part of its traverse.

The sutures may be of catgut, or of unabsorbable material—linen thread, silk or cotton, and they may be interrupted or continuous. While two-layer anastomosis is standard procedure one layer only the inner one may be used when time is pressing as when multiple resections of the small intestine are needed in an operation for an abdominal war wound or when the lumen is very small, as in resection for congenital malformations in infants.

When only one layer is used, the stitches should be interrupted and of unabsorbable material. On the other hand some surgeons advocate a three-layer anastomosis, the inner layer uniting mucous membrane only. Others add a third outer layer when they doubt the security of a two-layer anastomosis already performed; in such cases the third layer usually consists of a few interrupted stitches inserted here and there where the previous suture line seems to require reinforcements.

In all anastomoses certain technical principles are involved, and the interpretation of these principles varies from surgeon to surgeon and from time to time. Methods formerly used that we now consider clumsy were right at a time when suture materials were unreliable, anaesthesia was bad, resuscitation was little understood, and chemotherapy was non-existent. Two changes in thought may be mentioned.

Till lately the peritoneal coat was considered of extreme importance in intestinal anastomosis. Some surgeons used a special "mesenteric stitch" to close the "dangerous space" where the dividing mesentery left part of the bowel circumference uncovered; others rotated the two ends slightly so that the two "dangerous spaces" should not correspond. Today most surgeons bring the mesenteric angle of the loops to be sutured together, not for reasons of safety, but to facilitate neat closure of the gap in the mesentery. They consider that loops of uncovered bowel will unite just as well as loops of peritonealized bowel provided they are equally well sutured and not under tension. Another trend is that surgeons are tending to abandon lateral anastomosis, and to prefer end-to-end suture whenever possible. Secondary anastomosis, by apposing two loops of bowel and subsequently crushing the spurs between them has been discarded as a planned procedure, particularly in joining the small to the large intestine. Another method, once well supported, that is seldom advocated today, even in those storehouses of tradition, the text-books, is aseptic intestinal anastomosis. All so-called aseptic methods give imperfect apposition of the mucous coats and *imperfect control of haemorrhage. Whatever may be the causes of leakage or disruption at a suture line, sepsis is* not one of them.

Certain technical considerations are common to all anastomoses.

First, when two hollow viscera are to be anastomosed, they must be brought together and held together till the anastomosis is finished. In most cases this is attained by holding each in a clamp designed for the purpose, the two clamps being locked together or kept in apposition by other means. The clamps retain the viscera in apposition, and they prevent leakage and control haemorrhage when the openings are made. Some surgeons dislike clamps, believing they damage the edges forming the stoma. *There is no evidence in favour of such an assertion.* All intestinal clamps are designed with finely ridged inner surfaces to their jaws like the papillary ridges on the palmar surfaces of the fingers, so that they can hold slippery peritoneal surfaces with quite light pressure. For some reason known only to the nursing profession, theatre sisters insist on covering these delicate gripping surfaces with rubber tubing, thus converting holding clamps into crushing clamps. Properly used, clamps do no harm, and they enable the surgeon to select the site and the size of the openings that will take part in the anastomosis, and to keep them as he intended till the job is finished.

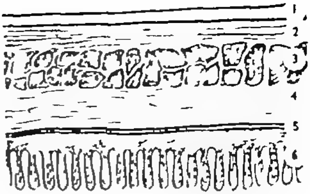
Secondly, since the anastomosis is made in two layers, the outer suture must first be inserted half way round the opening. The all-coats suture is then put in for the same extent, and carries on round the other side of the opening to its starting point. Lastly the outer suture is resumed where it was left and completed round the second half of the opening.

Thirdly the anastomosis, while it is being made in this manner, consists, not of two round openings facing each other, but of two slits laid side by side. Each slit has two edges and two ends, and each suture implies joining two edges, and turning two corners. The usual method is to start at one corner, join two edges with a continuous stitch, turn the first corner, join the two edges on the opposite side of the stoma, and *finish at the first corner where the suture line began.* In this method any discrepancies in the length of the two edges, due to inequality in the size of the openings or errors in the spacing of the stitches, are accumulated at the last corner, and tend to demand some unsatisfactory cobbling to adjust them. The corners are in any case the most difficult part of an anastomosis. A better method is to work with suture material carrying a needle at both ends, to carry the suture along one edge and round one corner, then to start with the other needle and round the other corner in the opposite direction. In this way the suture finishes in the middle of an edge where inequalities are easily spaced out.

THE PROCEDURE

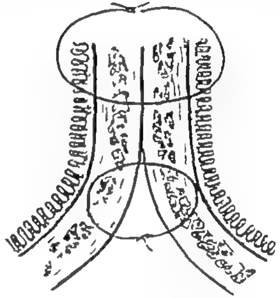
The structural pattern of the intestine

1 The coats of the intestine as shown are
(1) Peritoneum
(2) Longitudinal muscle
(3) Circular muscle
(4) Submucosa
(5) Muscularis mucosae
(6) Mucous membrane



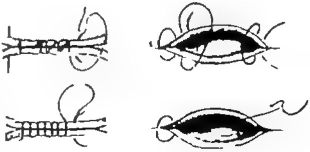
Sutures used in intestinal anastomosis

2 *Above* The all-coats suture
Below The sero-muscular or Lembert suture.



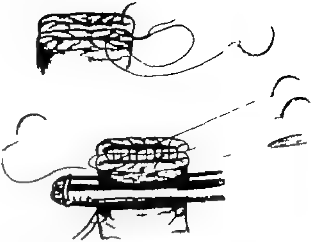
Types of sero-muscular suture are
3 *Left* Interrupted.
Centre Continuous.
Right Continuous mattress (Cushing)

Types of all-coats suture
4 *Left* Posterior layer *Above* Interrupted and continuous over-and-over sutures. *Below* Connell suture
Right Anterior layer two varieties of inverting suture *Above* Connell suture. *Below* Tyrrell Gray suture.



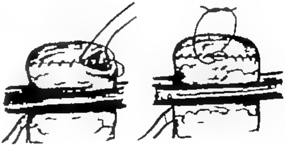
The start of the suture

10 A suture with a needle at each end is used for the all-coats layer
The suture is started at the first corner so that the knot is tied on the mucosal surface. It is continued along the posterior layer as a simple over-and-over stitch. The second corner is turned by taking the needle outwards from the lumen of the first loop inwards into the lumen of the second loop and then pulling tight on the mucosal surface.



The return layer

11 The return layer is continued as a Tyrrell Gray stitch, each time out from the first loop into the second, and pulling on the mucosa.
After continuing two-thirds of the way the first needle is passed outwards only and the suture is held there The second needle is picked up and used like the first, but in the reverse direction The corner is turned by passing the needle out from the second loop and in to the first, and each subsequent stitch takes a similar course and is pulled on the mucosal surface.
The two ends of the suture are tied together completing the invagination of the return layer



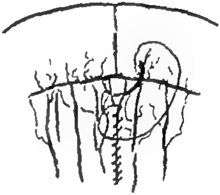
Reinforcing the all coats layer

12 The intestinal clamps are removed. The two ends of the sero-muscular suture are pulled apart to tighten up the suture line and the suture is then continued round the remainder of the anastomosis as a continuous Lembert stitch, inverting and reinforcing the all-coats layer and finishing at the first corner where it is tied to its commencement.

Closure of the mesentery

13 The gap in the mesentery is closed with a running peritoneal stitch, which ends at the mesenteric angle. This last stitch may take a bite of bowel wall as well as peritoneum.

To secure maximum neatness, the anastomosis should be turned over and the mesenteric gap should also be repaired from the other side.



[*The illustrations for this Chapter on Specimen Anastomosis of Hollow Viscera were drawn by Mr J Wheldon*]

GASTROSCOPY

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PRE-OPERATIVE

Indications

The main indication for gastroscopy is in the investigation of those cases of dyspepsia or upper abdominal pain which have been serious enough to have had a barium meal but in which the diagnosis is still in doubt. It is valuable in following the healing of gastric ulcers to completion. Craters less than $\frac{1}{4}$ inch in diameter and $\frac{1}{16}$ inch deep are difficult or impossible to show by radiography. It is useful in studying the degree of development of the mucosa, whether it is hypertrophic or atrophic as in the anaemias and malnutritions.

Special precautions and contra indications

Before attempting to pass the gastroscope it is a wise precaution to ensure that the oesophagus is normal radiologically. Gastroscopy is contra-indicated in the presence of ulcer, stenosis, distortion and neoplasia of the oesophagus; when spinal deformity is gross enough to prevent the alignment of the mouth, hypopharynx, oesophagus and cardiac orifice; in aortic aneurysms or other mediastinal masses deforming the oesophagus; in cases of oesophageal pouch and diverticulum; and when radiographs have shown a large growth involving the uppermost part of the lesser curve. The use of the Taylor gastroscope, which is 18 mm. in diameter, is unwise in any patient suffering from atrophy of the lingual mucosa, particularly if there is any dysphagia. The narrower Wolf Schindler instrument should be used in women over 60 years of age.

Pre operative preparation

Patients are examined in the morning after an overnight fast from food and drink. While the examination can quite easily be done on outpatients the mucosa of those who are in bed shows less irregularity of colour than in those who have made a journey to hospital the same morning. In these people the mucosa is often redder than normal and a diagnosis of gastritis must be made with greater caution.

Premedication and anaesthesia

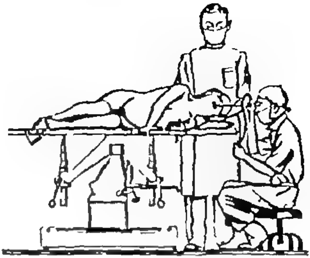
It was our usual practice in the average adult to give atropine, $\frac{1}{100}$ gr., and morphine, $\frac{1}{4}$ gr., $1\frac{1}{2}$ hours before examination. This is supplemented, if the respirations remained above 16 per minute $\frac{1}{2}$ hour before examination, with a further dose of $\frac{1}{4}$ gr. morphine. The lips, mouth and throat are anaesthetized by giving the patient in 3 or 4 driblets a total of 2 ml. of 1 per cent amethocaine hydrochloride, and by asking him to work it round his mouth and swallow.

Recently we have found it satisfactory to give local anaesthesia as above and to supplement this with up to 100 mg. of pethidine given intravenously on the examining table.

If the patient is unable to endure the discomfort of the procedure we give Pentothal and succinylcholine chloride and intubate with a cuffed endotracheal tube.

It is dangerous to try to do the examination quickly under Pentothal alone because the combined effect of the drug and the mechanical irritation often lead to a prolonged spasm of the glottis with deep cyanosis.

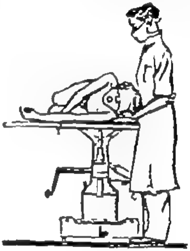
The stomach is usually empty at examination and is only evacuated by a tube if pyloric obstruction is known to be present. On rare occasions when the debris of gross retention has obscured the view it may be necessary to wash out the stomach before repeating the examination.



TECHNIQUE

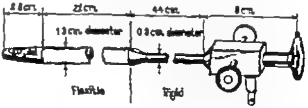
Position of the patient

1 The most generally useful position is a left lateral with the hips and knees well flexed and the pelvic and shoulder girdles at right angles to the table The head is held in the sort of position a man assumes when shaving the hyoid region before a mirror This position
2 is maintained throughout the examination A strong steady co-operative assistant is a boon to patient and examiner The patient is void of clothing in the illustration to show the most suitable position. The left arm is shown supported on an arm rest ready to receive a supplementary injection of pethidine. Special back rests and supports for the legs are helpful but not necessary



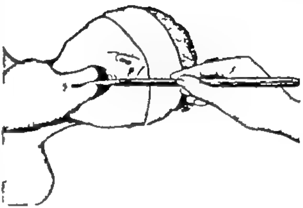
The gastroscope

3 Two types of gastroscope are commonly in use in this country The Wolf Schindler gastroscope (1932) and a modification of it by Taylor and Schranz (1941) (illustrated) Its flexible portion is shorter and wider than in the older model, and it can be flexed at will by the turning of a wheel near the eye-piece. Taylor's gastroscope gives a clearer view than Schindler's but being wider it is more likely to produce cricopharyngeal laceration



Introducing the gastroscope

4 The object is to pass the instrument as gently as possible down the oesophagus and into the stomach. No exact drill is applicable but as a rule two fingers of the examiner's left hand displace the tongue anteriorly and in so doing can assess how effective anaesthesia has been. The gastroscope, held like a pencil conveniently near the end, is passed into the mouth and advanced gently in the line of the hypopharynx. When this has been reached, gentle pressure is maintained to make it pass the cricopharyngeal narrows. If the patient is conscious and can be persuaded to swallow it makes this step easier. The instrument is advanced gently until the stomach is reached, the lens is directed to the patient's left and the stomach is distended by blowing in as little air as it takes to see the mucosa clearly. If too much air is put in the mucosa is carried away from the objective and may be difficult to see. During passage of the instrument the eyepiece is supported by the assistant.

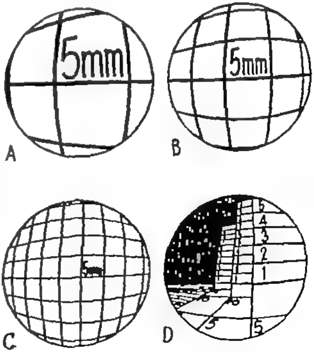


Perspective

5 The three views shown in A, B and C are of the same flat surface marked in 5 mm. squares and seen at distances of, respectively, 0·5 cm., 1·0 cm. and 2·0 cm. from objective lens. In D three identical panels are marked with horizontal lines 1 cm. apart and placed 5 cm., 10 cm. and 15 cm. from the lens.

The field is curved, being a little convex towards the observer. The detail at the periphery is smaller and may, in addition, be a little blurred.

As shown in D the perspective is exaggerated and beyond 15 cm. very little useful detail can be made out.



A routine procedure for inspection

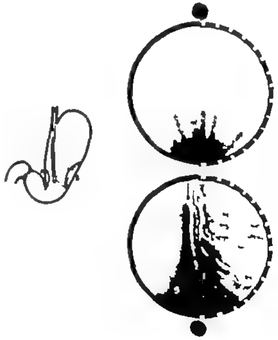
High level

6 It is convenient to divide the examination into two stages—that made on the way down with minimal distension of the stomach, and that made on the way back with greater distension. Three typical levels of inspection are illustrated. At the higher level the pool of mucus (A) which in the left lateral position collects in the splenic area at the most dependent point, is a clear landmark. Opposite the upper part of the lesser curvature (B) is seen. It is very close to the lens and so magnified in proportion to its nearness.

The field of view is shown on the diagram by a continuous black line when it appears on the anterior wall and a broken line on the posterior wall.

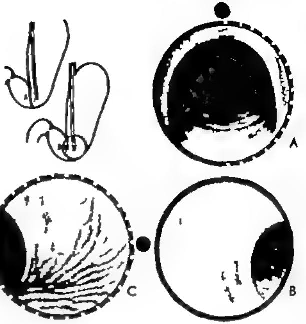
Middle level

7 At the middle level the lower part of the lesser curve of the body is clearly seen on looking to the patient's right and anteriorly while opposite is the greater curvature the diagram shows very diagrammatically the rugosity of the posterior wall and the smooth anterior wall. At this level a good close-up view of the mucosa can be obtained and a satisfactory assessment of the degrees of mammillation of the surface and the finer irregularities associated with the wear and tear changes of trauma and inflammation. Also at this level the height and development of the mucosal folds should be assessed. They provide an indication of the volume of acid secreting parenchyma and so of the potential secretion.



Low level

8 At the low level, when looking to the right, the pyloric antrum (A) is seen, and should be observed for long enough to trace a complete wave of peristalsis from its origin until it reaches the pyloric sphincter and relaxes. As it passes down, the mucosa on its proximal face can be inspected more clearly than it can in the resting phase. By rotating the objective lens anteriorly the anterior wall near the lower pole of the stomach (B) can be seen and opposite this the posterior wall (C). In this position a gastro-enterostomy opening is usually found.



Transverse and elongated types

9 The view depends to a large extent, especially in the antrum, on the shape of the stomach. In the transverse steerhorn type of stomach (A) a good view of the sphincter region is obtained, while in the elongated type (B) an extreme example of which is shown, no view of the sphincter region is possible.

This inability to see the lesser curvature between the angulus and the pyloric sphincter is a great drawback in the elongated stomach. Other blind areas lie (1) at the lower pole of the stomach, beyond the tip of the instrument, when the usual type of gastroscope illustrated here is employed, (2) the cupola of the fundus especially in its medial half, and (3) those areas of the upper lesser curve which lie too close to the objective lens. The Taylor gastroscope is particularly useful in diminishing the last of these blind areas.

POST-OPERATIVE COMPLICATIONS

The patient should not be allowed food or drink until the anaesthesia of the pharynx has recovered. The only common complication is soreness of the throat for a day or two

Oesophageal tear or perforation

In a series of 49 000 gastroscopies collected by Avery Jones (1951) *et al* there were 60 cases of damage to the oesophageal wall severe enough to produce peri-oesophageal inflammation. Of these 60 21 died, most of them before penicillin had come into use In the great majority of these cases the damage was at the upper end of the oesophagus, was produced by the Taylor instrument and occurred in patients over 60 years, ten times more frequently in women than in men. It is most likely in the presence of atrophy of the pharyngeal mucosa, especially if there is any fibrous narrowing of the lumen

The patient suffers pain in the neck from the time of instrumentation. It is aggravated by swallowing and accompanied by pyrexia, stiffness of the neck, tenderness and swelling of the cricopharyngeal region from where surgical emphysema may spread over a considerable area. Treatment, which should be commenced without delay consists of parenteral feeding a single dose of 2 g of sulphadimidine paste, penicillin in adequate doses and morphine or another sedative to help the patient to keep still. If improvement is not obvious in 24 hours a drain should be put down to the level of the cricopharyngeus on the more painful side. This is best done by a collar incision as for thyroidectomy

Other risks are perforation of the stomach, haemorrhage and over-use of the local anaesthetic. All these together accounted for 1·4 deaths per 10,000

[*The Illustrations for this Chapter on Gastroscopy were drawn by Mr G Smith.*]

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PYLOROMYOTOMY IN INFANTS

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PRE-OPERATIVE

Indications

Pyloromyotomy is indicated in all cases of congenital hypertrophic pyloric stenosis when the vomiting is severe, when the baby is losing weight and when there is dehydration. Medical treatment is reserved for mild cases in which the weight is being maintained and the obstruction is minimal as shown by the passage daily of a satisfactory stool In such cases operation is indicated if vomiting increases, if the weight begins to fall and if the stools become smaller in amount and less frequent.

While the operation is not an emergency one it need not be delayed unless there is evidence of severe dehydration or of alkalosis. In such cases the operation should be deferred until the disordered chemical and water balance has been corrected.

Prematurity is not a contra-indication to operation and, indeed, operation gives these small babies the best chance for the rapid return to normal feeding which is so essential.

Pre-operative preparation

The baby must be nursed in a cubicle or if cubicles are not available, by a strict barrier nursing regime When the condition of the baby is good parenteral fluid therapy is not required. When there is only slight dehydration the subcutaneous infusion of 10 ounces of half normal saline in 5 per cent glucose with hyalase to aid absorption should be given during the 24 hours before operation.

In severe cases of longer standing the dehydration alkalosis, potassium deficiency and even tetany may be corrected by intravenous therapy which should be controlled by frequent biochemical investigations. This should be done as quickly as possible in order that operation and therefore a return to normal feeding may not be long delayed.

In all cases the stomach is cleared of food residue and mucus by gastric lavage with normal saline an hour before the operation. In severe cases with a grossly dilated stomach gastric lavage may be required on several occasions.

If local analgesia is to be employed the baby is placed in position on a pyloric crucifix or board before being taken to the operating theatre

In breast fed babies the mother should be admitted to hospital with the child and lactation should be maintained in readiness for the return of the baby to normal feeding

Anaesthesia

General anaesthesia with cyclopropane and oxygen is ideal in expert hands. Atropine is avoided pre-operatively because of the greater risk of post-operative pyrexia and hyperpyrexia. Pre-operative sedation is withheld in order that the reflexes may be fully active before the baby leaves the table Gas oxygen and ether or open ether are also satisfactory

Local analgesia is employed in some hospitals but has the disadvantage that the baby may cry making the wound closure difficult because of prolapse of the gut or omentum. To avoid this, pre-operative sedation may be employed but is often unreliable Some surgeons reserve local analgesia for the bad risk cases but general anaesthesia is safe both in premature and in malnourished babies.

Position of the patient

The baby lies supine with a small pad of wool placed like a gall bladder bridge. The skin of the lower thorax and the whole of the abdomen is prepared, special care being directed to the umbilicus.

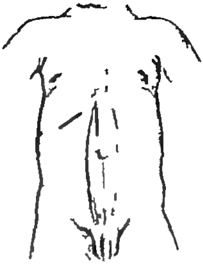
THE OPERATION

The incision

1 A high right paramedian muscle-splitting incision about 2 inches long the upper half at least of which lies above the anterior border of the liver

Alternative incisions

Alternative incisions are a similar paramedian incision with lateral displacement of the rectus muscle One similar to the above but the posterior rectus sheath and peritoneum are incised transversely to give a gridiron effect. Also a small upper transverse incision, and the subcostal gridiron incision described by Robertson and employed by Gross (1953)

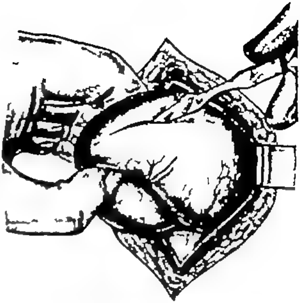


Exposure and delivery of the pylorus

2 All bleeding points are ligated and skin towels applied. The peritoneum is opened and the liver is exposed in the upper part of the incision while the transverse colon may be visible at its lower end. The lower border of the liver is gently elevated, the pylorus identified and delivered by gentle traction on the stomach with Babcock's forceps. Should the surgeon have any difficulty in finding the pylorus the omentum or transverse colon may be followed upwards to reach the stomach.

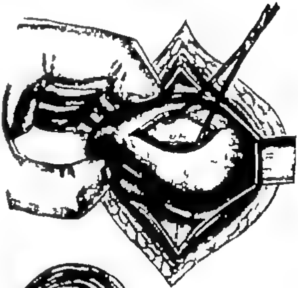
Incision of the pylorus

3 The vessels of the pyloric tumour are examined. They pass upwards and downwards from the upper and lower borders of the pylorus leaving an avascular area on the supero-anterior aspect of the tumour. The pylorus is steadied by finger and thumb applied to either side of the duodenum just distal to the pylorus. A longitudinal incision is made in the avascular area commencing proximal to the pyloric vein to avoid opening the duodenum and continuing proximally to divide the gastric muscle above the tumour.



Widening the incision

4 The incision extends down to the submucosa. The edges of the cut muscle layers are spread widely by forceps until the mucosa bulges freely through the incision. Care must be taken at the distal end of the incision to secure complete separation of the muscle without injury to the duodenal mucosa. To facilitate this the pyloric tumour is gently pushed proximally by the finger and thumb on either side of the duodenum.

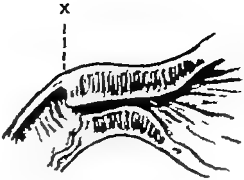


Transverse sections

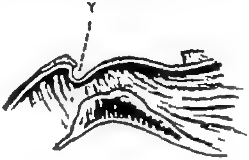
5 The result of the operation is shown by the transverse sections of the pylorus before and after pyloromyotomy.

Longitudinal sections

6 The upper figure represents a longitudinal section through the pylorus at the site of the incision. It demonstrates the fornices of duodenal mucosa produced by the projection of the pylorus into the duodenum. X marks the dangerous area where the mucosa is adherent and the incision must begin proximal to this point.



7 The lower figure represents a longitudinal section of the pylorus through the long axis of the completed incision. When the pylorus is gently pushed proximally by the finger and thumb through the duodenum the narrowing of the mucosa at point Y is clearly seen and indicates satisfactory separation of the pyloric muscle.

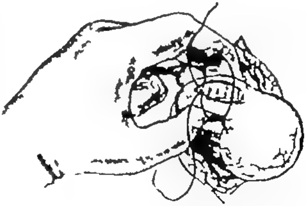


Opening the duodenal mucosa

8 Normally this should not occur but it is not a serious complication when recognized and closure carried out immediately. To ascertain that the mucosa is intact the duodenum should be gently squeezed. As a rule there is no bleeding from the incision but occasionally it is necessary to ligate one or even two small vessels.

Closure of the wound

If haemostasis is satisfactory the pylorus is returned to the abdominal cavity and the wound is closed in layers.



POST-OPERATIVE CARE AND COMPLICATIONS

Over-heating

The baby is observed closely care being taken to avoid over-heating temperatures of over 102 F being lowered as quickly as possible. Sedation is not required.

Nutrition

Oral feeding is resumed 6 hours after operation when 2 drachms of glucose water or half strength Ringer lactate solution may be given. Thereafter the amount is gradually increased and after 24 hours the baby is on small 2-hourly feeds of breast milk or formula. Twenty-four hours later the baby should be capable of taking 8-ounce feeds and if breast fed may be returned safely to its previous regime. As all surgeons and paediatricians have their own post pyloric schedule it is not necessary to give full details here.

Vomiting

The baby may regurgitate a little following operation but vomiting is unusual after 48 hours. It is usually 3 or 4 days after the operation before the bowels move and no attempt should be made to secure an earlier stool. If vomiting persists after operation and is not accompanied by diarrhoea the most likely cause is inadequate division of the pyloric muscle.

Infection

Cross infection especially gastro-enteritis, is a hazard particularly in dehydrated and malnourished babies. This danger is largely eliminated by strict isolation of these patients. Post-operative vomiting accompanied by loose stools should be regarded as due to infectious gastro-enteritis and should be treated immediately without awaiting bacteriological confirmation.

Wound disruption

Wound infection is a rare complication which should be eliminated by strict operative and isolation technique. Wound disruption was a not infrequent complication when surgical treatment was reserved for debilitated babies in whom medical treatment had failed. It may still occur in rare instances but should be avoided by taking great care that the filmy omentum does not insinuate itself between the peritoneal sutures and by the use of non-absorbable sutures in the anterior rectus sheath.

Recurrence

Recurrence of the condition has been described (Macrae-Gibson and Coles, 1958) The persistence of symptoms is more likely to be the result of inadequate pyloromyotomy and care must be taken to secure complete division of the pyloric muscle.

[The illustrations for this Chapter on Pyloromyotomy in Infants were drawn by Mr J Wheldon]

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GASTROSTOMY

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PRE-OPERATIVE

Indications

Temporary gastrostomy may be necessary in cases of oesophageal burns by corrosives, in wounds involving the pharynx or cervical oesophagus, in severe inflammatory conditions preventing swallowing and before irradiation of a carcinoma of the gullet. It is occasionally indicated for the purpose of restoring nourishment before radical removal of some lesion obstructing the oesophagus such as a mediastinal cyst or before dilating with bougies a totally obstructed benign stricture.

Permanent gastrostomy is sometimes indicated for incurable conditions of the larynx, pharynx or oesophagus which are causing total obstruction to swallowing but which are not expected to destroy the patient within a few months.

Contra indications

Gastrostomy is not indicated when fluids can still be swallowed, for a diet adequate in calories and proteins is then readily taken. Nor should total obstruction be considered to have occurred until oesophagoscopy has established that no solid food is impacted in the lumen and, in cases of growths, the equally dangerous, but no more dangerous, procedure of dilatation through the oesophagoscope has been attempted and has failed.

Gastrostomy should not be used when there is any chance that at subsequent operation the stomach may need to be brought into the thorax to replace resected oesophagus or to establish a by pass, jejunostomy being then preferred.

In congenital atresia, a fistula commonly connects the trachea with the distal segment of the oesophagus, and gastrostomy is liable to lead to regurgitation and aspiration pneumonia. It should, therefore, not be used before exploration in this condition.

Inoperable carcinoma of the oesophagus is better managed by the insertion of a Souttar s tube when possible than by gastrostomy and this may be considered before irradiation too

In patients with carcinoma of the oesophagus or gastric cardia for whom neither surgery nor irradiation are to be attempted and who can no longer swallow their own saliva, gastrostomy can only prolong a state of extreme misery The further anguish of dehydration should be dealt with instead by rectal infusion.

Special apparatus

A size 12 (English gauge) Jacques catheter or a 12-inch length of rubber tube of similar diameter with a spigot.

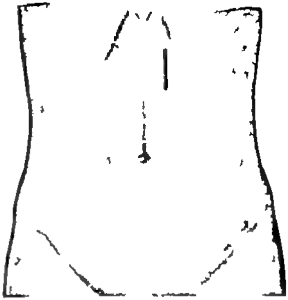
Pre operative preparation

The post-operative mortality from gastrostomy is high and patients should be made as fit for the undertaking as possible by rectal or intravenous infusion. If blood can be spared, a transfusion will usually be indicated otherwise plasma may be given.

The oesophagus should be emptied, as far as possible, by aspiration through a wide-bored tube to diminish the dangers of regurgitation during the induction of anaesthesia and before the recovery of consciousness.

Anaesthesia

Local anaesthesia is usual for the serous-lined gastrostomies For the more complicated permanent operations, general anaesthesia is likely to be required instead or in addition.

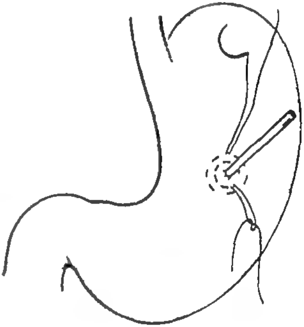


TEMPORARY SEROUS-LINED

STAMM S PROCEDURE

The incision

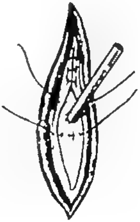
1 A 3-inch incision, splitting the top of the left rectus abdominis, is made. The gastric wall should present, but colon may appear first when the stomach is very shrunken sufficient bowel must therefore be delivered to make sure by the absence of taeniae that no mistake has been made.



Insertion of the catheter

2 Two No 2 silk purse string sutures are placed, the first making a ring ½ inch and the second 1 inch in diameter A hole large enough to admit a size 12 catheter is made in the sero-muscular coats. The mucosa is picked up with forceps and opened with scissors. The mucosa must not be released until the catheter has been inserted. The catheter is fastened to the edges of all layers with a silk stitch.

The purse string sutures are drawn tight and tied in turn, the catheter being advanced into the stomach as each is tied so as to achieve an ink-well" inversion.



Attachment of the gastric wall

3 The peritoneum and posterior rectus sheath are closed with interrupted sutures of No. 1 or No 2 chromic catgut. Adjacent to the tube the stitches are also made to pick up two good bites each of gastric wall. The skin is closed with interrupted, end-on mattress sutures of nylon or silk-worm gut.

WITZEL'S PROCEDURE

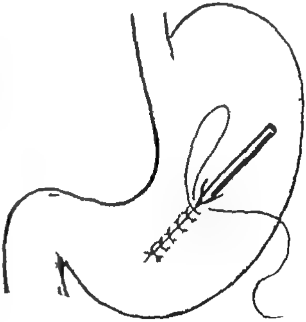
Insertion of the catheter

4 The tube is inserted into the stomach in a similar fashion but nearer the pyloric end It is tethered by a stitch transfixing the tube and all coats of the stomach, and by a single purse string suture

Enfolding the tube

5 The tube is now laid along the long axis of the stomach and buried by drawing two folds of gastric wall together over it with a continuous sero-muscular suture. A second row may be added if considered necessary If in a shrunken stomach difficulty is experienced in raising up the two ridges of gastric wall, the serous and part of the muscular coat may be incised and the tube buried in the incision.

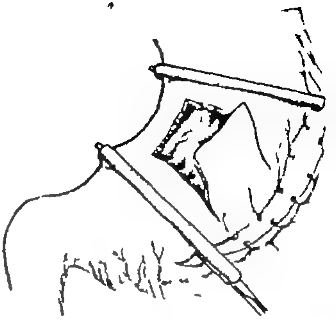
The peritoneum and posterior rectus sheath adjacent to the exit of the tube from the stomach and abdomen are attached to the gastric wall as described for Stamm's gastrostomy



PERMANENT, MUCOUS-LINED

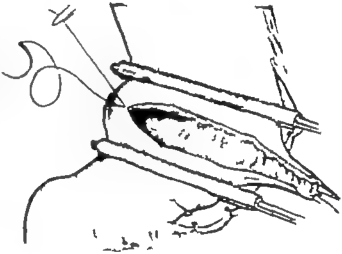
JANEWAY'S PROCEDURE

The making of a gastric flap



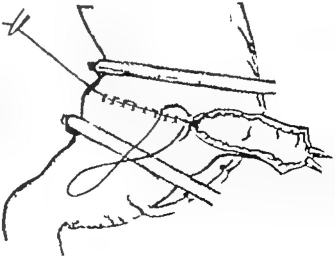
6 The great omentum is separated from the stomach from the antrum to the lower pole of the spleen. Gastro-enterostomy clamps are applied to the stomach 4 or 5 inches apart. A flap 2 inches broad is outlined on the stomach by an incision down to the submucosa. All visible vessels are twice underrun and tied off and the mucosa opened between these ligatures all round the edge of the flap The clamps should now be opened for a moment, one at a time, so that any large bleeders which have been missed may be picked up and tied off

Tubular distortion of the flap



7 An "00 catgut all-coats suture is now begun at the centre of the lesser curve edge of the aperture from which the flap has been lifted and two Babcock or Allis forceps are placed on *the end of the flap The assistant picks* up the tail of this suture and by distracting this and the Babcock forceps, distorts the aperture as illustrated, while the operator makes this easier by moving the two gastro-enterostomy clamps towards one another

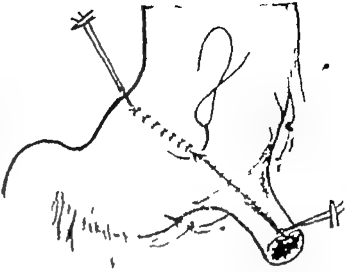
Construction of the tube



8 The two edges of the opening in the stomach are now sutured together by a continuous over-and-over stitch, the suture being pulled tight each time it emerges on a mucosal surface while a finger is pressed on the serous aspect to produce inversion. This suture is continued on to unite the edges of the flap in a similar manner so converting it into a tube.

Second layer of sutures

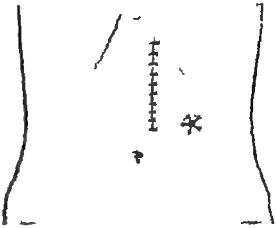
9 A sero-muscular layer of sutures of No 1 or 2 silk is now inserted to bury the all-coats layer and these are best interrupted so as to minimize loss of elasticity of the tube and so facilitate its attachment to the abdominal wall



Position of the stoma

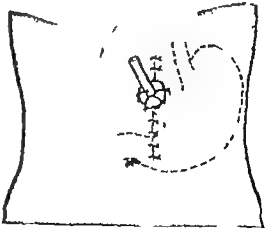
Lateral to the incision

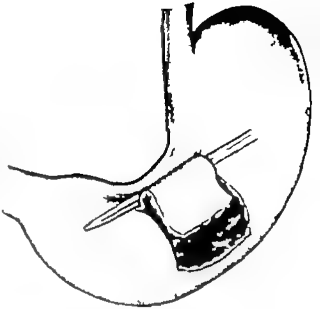
10 The tube is brought out through a suitably placed separate aperture and the mucous lining of the tube sewn to the skin edges by interrupted silk or salmon-gut sutures.



Within the incision

11 Janeway's method may be reversed, so placing the stoma at a higher level and reducing any tendency to leakage. It may then be convenient to place the stoma at the upper end of the original incision This is the method most favoured by the writer





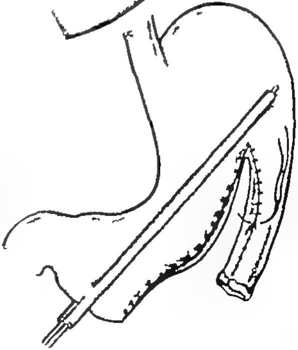
SPIVACK'S PROCEDURE

Formation of a gutter

12 This method is complicated, but is claimed to be leak-proof. By laying a haemostat on the gastric wall near the lesser curve and sewing the wall to itself across the instrument, a gutter is formed and a ridge raised inside the stomach. A flap of gastric wall is now formed, as in the Janeway's operation with this ridge at its base.

Formation of the tube

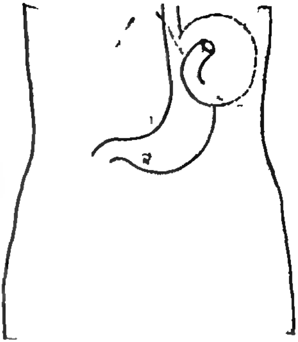
13 The aperture so created is distorted and sewn up as in the Janeway's operation, and the ridge will thus be caused to curl round and become joined to itself end to end. A valve is thus created where the tube arises from the stomach. The tube is brought out at the upper end of the original incision as in the reversed Janeway's operation.



BECK JIANU PROCEDURE

Formation of the tube

14 In this method a longer tube is formed than in any previous gastrostomy in fact it is long enough to be folded round the costal margin. It is important to preserve the left gastro-epiploic artery and the vascular arcade down to the end of the tube in order that it may be adequately supplied with blood. The stomach and tube may be closed with one continuous catgut suture and a second row of interrupted catgut or non-absorbable sutures inserted.



Formation of the stoma

15 The tube is then drawn up subcutaneously to come out through a stab wound as high as can be achieved without tension. Direct mucocutaneous suture with nylon or silk worm gut is again used at the stoma.

JEJUNAL SEGMENT METHOD

Pedicled segments of jejunum have been used successfully to form gastrostomies in laboratory animals, and they do not leak provided they are placed so that peristalsis goes from skin to stomach. They are not recommended for human subjects, however, because of the risk of jejunal ulcer at the gastric end of the tube.

POST-OPERATIVE CARE AND COMPLICATIONS

Gastrostomy feeds should begin at once, since leakage of acid gastric juice, unbuffered by food, is more dangerous than leakage of sterile feeds.

Patients undergoing gastrostomy are usually grossly wasted and deficient in protein and minerals. They therefore need diets of extra high calorie value and protein content and in due course mineral and vitamin deficiencies must be made good.

As an example, a basic diet worth about 3,000 calories and containing 140 g. of protein is provided by 3 pints milk, 6 eggs, 5 oz. cream and 6 oz. full cream dried milk powder. To this must be added 10 g. of sodium chloride. In addition the patient will require extra iron, vitamin C or fruit juice, the vitamin B complex and sufficient water to make up the total intake to 4 or 5 pints.

At first, half-hourly 3 oz. feeds should be given and the interval between feeds lengthened as the stomach capacity increases and the suture lines become soundly healed.

The skin around the stoma should be kept coated with silicone ointment to afford protection should spillage of gastric juice occur.

Special care must be taken to see that the tube does not get pulled out until sound union of skin edges promises similar sound union of internal suture lines, and it should be amply tethered with strapping.

Death after gastrostomy is common, since the patients subjected to this operation are in worse condition than those for whom any other is undertaken.

The most frequent cause of death is peritonitis from leakage due to poor healing, often contributed to by separation of the stomach from the anterior abdominal wall. This is not uncommonly the result of attempts to re-introduce a tube which has escaped from the gastrostomy or been pulled out by an uncooperative patient.

The tube must never be left out of a serous-lined gastrostomy, for the aperture shrinks rapidly. This does not apply to mucous-lined gastrostomies.

[*The illustrations for this Chapter on Gastrostomy were drawn by Miss H. Wilson.*]

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SIMPLE CLOSURE OF PERFORATED PEPTIC ULCER

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PRE-OPERATIVE

Indications and contra-indications

There is some divergence of opinion on the best treatment of the perforated peptic ulcer Three possible courses of action will probably come under consideration (1) non-operative treatment with continuous gastric suction, sedation, intravenous fluid replacement, and antibiotics (2) laparotomy and simple closure of the perforation (3) laparotomy and partial gastrectomy

It is a matter of individual preference which of these is selected. Although some surgeons advocate routine conservative treatment for perforation, most believe that surgery should be undertaken except in the case of a recent perforation complicated by coincident grave systemic disease. The patient gravely ill with a late perforation and established peritonitis may well die with any form of treatment, but might get better with surgery and will almost certainly die with non-operative treatment.

Gastrectomy is often preferable to simple closure of a perforated gastric ulcer particularly if the ulcer could conceivably be malignant. In many cases of perforated chronic duodenal ulcer too gastrectomy can be performed without undue technical difficulty and is the most suitable procedure.

The reader is referred to Herman Taylor's original paper on conservative treatment (1946) and to a useful comparison of figures compiled by Heslop and others (1952)

Pre-operative treatment

In the early perforation, shock is largely due to pain. A full dose of morphine is given intravenously if peripheral vasoconstriction is marked. When this has taken effect a Ryle's tube is passed into the stomach, continuous gastric suction started, and an intravenous drip is set up

Anaesthesia

Light general anaesthesia with an intravenous relaxant is usually employed. Occasionally local anaesthesia is considered preferable

Operative exploration for the location of the perforation

A midline or right paramedian incision is usual. When the peritoneal cavity is opened, the correctness of the diagnosis is shown by the escape of gas and liquid. In the past, it has sometimes been taught that peritonitis is likely unless time is spent upon careful cleansing of the peritoneal cavity It is clearly right to remove obvious food debris and to use a sucker to extract the turbid fluid obscuring the viscera, *much of which has not escaped through the* perforation but is an exudate from the irritated peritoneum, but it is quite unnecessary to tip the patient in various directions and explore every nook and cranny of the peritoneal cavity in order to suck out every drop of fluid. Adequate retraction and the use of a sucker allow the rapid exposure to view of the anterior surfaces of the stomach and duodenum In most cases the site of perforation is at once apparent. Occasionally a very high perforation or posterior perforation into the lesser sac may call for a more prolonged search.

THE OPERATION

PERFORATED DUODENAL ULCER

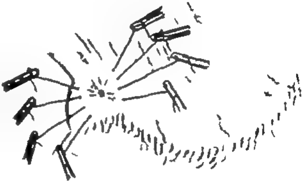
"Omental patch" technique Initial suture

1 The stiff oedematous duodenal wall adjacent to a perforation holds sutures poorly and is often too rigid to be easily drawn together over the perforation itself Moreover any procedure which might lead to narrowing at a point already in danger of later stenosis is contra-indicated. Purse-string sutures or Lembert sutures are therefore best avoided. The simplest and best way of closing a duodenal perforation is by the "omental patch" technique

Using fine silk or fine catgut mounted on a curved round-bodied or eyeless needle a suture is inserted just above the ulcer

Further sutures encompassing the perforation

2 Two or three similar sutures, dependent upon the size of the perforation are inserted to encompass it and the ends held in haemostats. These sutures should pierce the duodenal wall well clear of the perforation itself, entering and leaving the duodenal lumen at points clear of the actual ulcer bed.



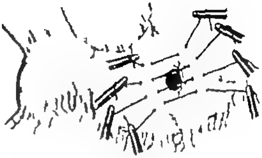
Fixing omental fat over the perforation

3 An adjacent piece of omental fat is drawn over the perforation and fixed in place by tying over it the sutures already inserted. These should be tied firmly but not tightly enough to cut through the oedematous duodenal wall. This is a far better method than tying the sutures first, closing the perforation, and then tying them again over an omental patch, for this merely leaves the omental patch fixed superficially to the knots of the sutures and in any event the edges of the perforation frequently cannot be drawn together without the sutures cutting through.

PERFORATED GASTRIC ULCER

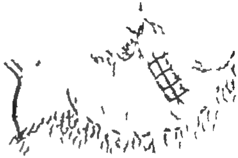
Encompassing the perforation with sutures

4 Perforations of or adjacent to the pylorus should be closed with an "omental patch". A larger perforation on the body of the stomach is much less common and frequently, as already stated, better treated by gastrectomy. If simple suture is, nevertheless, to be performed, the greater redundancy of the gastric wall and the smaller risk of causing narrowing of the lumen allow closure with Lembert sutures. Four silk sutures are inserted as shown.



Inversion of the perforation

5 These are tied firmly but not tightly, inverting the perforation, as shown, between two ridges of the stomach wall. Alternatively, a purse-string suture placed through normal stomach wall around the perforation may be employed.



Method using the "omental patch" technique

6 The "omental patch" technique is also a reasonable way of closing a gastric perforation, or an omental patch may be used additionally to buttress the sutured perforation. The abdomen is closed without drainage, unless operation upon a late perforation has opened up a localized perigastric abscess.

POST-OPERATIVE CARE

Gastric suction and fluid replacement

Gastric suction and intravenous fluid replacement are continued post-operatively for a variable period After closure of an uncomplicated early perforated duodenal ulcer nothing is given by mouth and continuous suction applied for 24 hours, after which hourly 4 ounce feeds are given the residue from each being withdrawn by suction just before the next feed. This intermittent suction and the intravenous drip can often be omitted after a further 24 hours, when the decline in the volume of aspirated fluid and the return of peristaltic sounds signal the return of normal gastro-intestinal function, although duodenal obstruction from oedema may occasionally cause delay in reaching this stage for up to a week. Not all surgeons give fluids intravenously to the patient with a recent perforation closed surgically For many it is only necessary to give parenteral fluids because the normal oral intake is interfered with by the necessity for employing gastric suction Some surgeons omit the intravenous infusion and use a rectal drip during the first 24 hours post-operatively after which fluids by mouth are allowed

Chemotherapy

With the inevitable contamination of the peritoneal cavity and of all layers of the wound, prophylactic chemotherapy is usually employed, penicillin (500 000 units) or streptomycin (0 5 g) or both being given 12 hourly

Pulmonary complications

The relatively high incidence of post-operative pulmonary complications is an added reason for prophylactic chemotherapy and also calls for an early start to post-operative breathing exercises and forced coughing A major atelectasis not responding to treatment within 24–36 hours should be solved by bronchoscopy

Other pulmonary complications, such as lung abscess, are less common Venous thrombosis occurs infrequently but particularly in the aged or more cachectic patient, and may be followed by pulmonary embolism. Routine treatment with anti-coagulants is usual

Management in the case of late perforation with peritonitis

The late perforation with established peritonitis calls for energetic treatment of the peritonitis along standard lines, with prolonged suction and intravenous drip replacement, antibiotics and blood transfusion.

Other complications

Local intra-abdominal abscess is comparatively common. This may develop in the pelvis or in a subphrenic space less commonly centrally placed in the peritoneal cavity shut off by adhesions between omentum mesentery and coils of bowel. An abscess of this kind usually produces a swinging temperature 7–10 days after operation and eventually requires drainage.

Sepsis in the deeper layers of the wound is also a not infrequent complication and often leads in the end to an abscess which may discharge spontaneously or require incision.

Pyloric obstruction may well occur precipitated by oedema, but seldom requires surgery It is usually temporary and is relieved once the local inflammation and oedema subside with gastric suction

[*The illustrations for this Chapter on Simple Closure of Perforated Peptic Ulcer were drawn by Mr F Price*]

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GASTRO-DUODENOSTOMY, PYLOROPLASTY AND PYLOROMYOTOMY

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PRE-OPERATIVE

Indications

Gastro-duodenostomy is indicated in cases of pyloric obstruction in which gastrectomy is contra-indicated and gastro-jejunostomy is technically impossible.

Finney's pyloroplasty may be employed as an alternative if difficulty is experienced in bringing the duodenum and gastric antrum together for a sufficient distance.

Mikulicz's pyloroplasty should be used after an inspection gastro-duodenostomy or after the duodenal mucosa has been accidentally opened in attempting a pyloromyotomy for fear that the alternative repair in the long axis might cause pyloric narrowing. However an inspection gastrostomy should not transgress the pylorus if this can be avoided.

Pyloroplasty with excision of the ulcer has been recommended in conjunction with vagotomy for small lesions of the anterior duodenal wall, but most surgeons prefer to combine gastro-jejunostomy with vagotomy when gastrectomy is contra-indicated.

Though these older forms of pyloroplasty are now seldom performed, the indications for pyloromyotomy without opening the mucosa, have widened and the operation is gaining in popularity Long-term reports on its dependability are, however not yet available

Pyloromyotomy is recommended in adult (as well as infantile) hypertrophic, pyloric stenosis, as part of an operation for reflux oesophagitis with gastric retention but no evidence of duodenal ulcer and as part of any operation, such as oesophagectomy which has involved division of the vagus nerves with preservation of the pylorus.

Contra indications

Gastro-duodenostomy and open pyloroplasty throw the gastric and duodenal cavities into one, thus exposing the duodenal mucosa constantly to the acid gastric contents. They are even worse in this respect than gastro-jejunostomy in which the stoma is more certainly bathed in the whole of the alkaline bile and pancreatic juice Gastric hyperacidity is therefore a contra-indication to these operations. In the presence of gastric retention a high level of total acidity indicates hypersecretion whether there is free hydrochloric acid present or not.

Pre operative preparation

If the patient has pyloric obstruction he is likely to be dehydrated and alkalotic. Anaemia and severe constipation are also commonly present. Normal blood volume and electrolyte balance should be restored before operation is undertaken if necessary by intravenous infusion of saline solution. This may result in lowering of the haemoglobin level, and the necessity for blood transfusion will therefore be re-assessed after dehydration and electrolyte deficiency have been corrected.

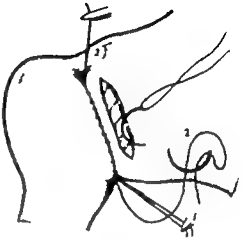
GASTRO-DUODENOSTOMY

Drawing together of the pyloric antrum and duodenum

1

The duodenum is mobilized by incising the peritoneum at its outer aspect. The pyloric antrum of the stomach and the duodenum are drawn together and joined by a silk stay suture (1) 2½ inches below the pylorus. A continuous silk, sero-muscular suture (2) is then started just below the pylorus. The assistant distracts the stay suture and the tail of the continuous suture while this suture is being introduced. When it reaches the lower end, it is tied to the stay suture. The assistant then renews his control.

An incision is made through the serous and muscular coats of the stomach ¼ inch away from, and parallel to the suture line, ending ¼ inch short of the ends of the suture line. The vessels of the sub-mucosa so exposed are each twice under-run and tied off

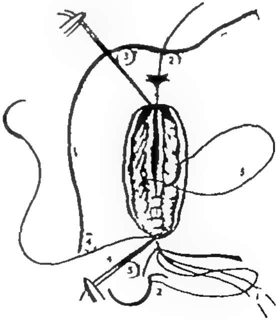


Opening of stomach and duodenum

2

The stomach and duodenum are opened and the top angles of the openings joined by a catgut, all-coats stay suture (3) Two catgut sutures (4 and 5) on atraumatic needles are started at the bottom angle and knotted together The assistant now lays aside the silk ends and, instead, picks up and distracts the catgut stay suture (3) and the tails of the two catgut sutures (4 and 5)

The operation is now completed exactly the same as for gastro-jejunostomy

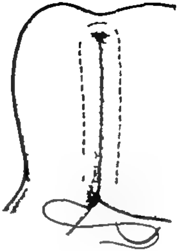


PYLOROPLASTY

FINNEY'S PYLOROPLASTY

Horse shoe incision

3 In Finney's pyloroplasty the top sero-muscular suture is a purse-string which takes a bite or two of the pylorus itself and securely closes the top angle between stomach and duodenum. After the first sero-muscular layer of sutures has been placed, the opening is carried right round horse-shoe fashion laying open the pylorus. This has the considerable disadvantage that the repair includes scar tissue. On the other hand, it provides a larger stoma if apposition of duodenum to stomach for sufficient distance proves difficult.



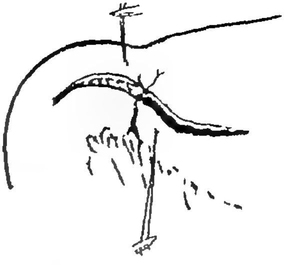
Closure

4 Catgut all-coats stay sutures are placed at top and bottom angles and a single, catgut suture is begun at the top of the posterior layer When it reaches the lower end it is tied to the bottom stay suture it then turns the corner and is continued as the anterior layer finishing by being tied to the top stay suture.

The sero-muscular layer is now completed, finishing by being tied to itself at the top end. A few extra interrupted sutures will usually be required to effect safer closure and infolding of the upper part, and omentum should be sewn over where scar tissue has been stitched to scar tissue.

MIKULICZ'S PYLOROPLASTY

In Mikulicz's pyloroplasty a straight incision some [illegible] or 8 inches long was used. This was then distorted and repaired in the transverse axis. Complete and permanent destruction of the pylorus resulted. In the modified version described, the pyloric muscle is lengthened but not absolutely ablated.



Placing of stay sutures

5 Two stay sutures are placed at least ½ inch apart, the top one at the duodenal edge and the bottom one on the gastric side of the pylorus. A sigmoid incision is made between them not more than 1½ inches long, dividing the pyloric ring obliquely.

Bleeding vessels are picked up and tied off.

Distortion of incision

6 The stay sutures are separated transversely so that the opening in the bowel is distorted into the transverse axis. It is then closed with a continuous catgut suture taking all coats of the duodenum but only the mucosal coat of the stomach.

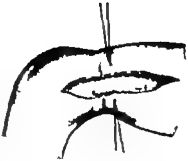
Closure

7 The first layer of sutures is now buried by a sero-muscular layer which draws the edge of the sero-muscular coat of the stomach across the first layer and attaches it to the duodenum 0.5 cm. beyond.

PYLOROMYOTOMY

Placing of sutures and serosal incision

8 Silk stay sutures are placed just on the gastric side of the pylorus, $\frac{1}{4}$ inch apart. A straight incision through the serosa is made between them $1\frac{1}{2}$ inches long, 1 inch on the stomach and $\frac{1}{2}$ inch on the duodenum. The transverse muscle fibres then present.



Division of muscle layers

9 When the muscle layer is divided, particular care is taken to sever all the fibres of the pyloric ring where the muscle is thickest. Here special caution is necessary to avoid opening the mucosa, for a fornix of the duodenal lumen usually overlaps the pyloric ring. The scalpel should therefore be used with its tip towards and its handle away from the operator.

Procedure on opening the mucosa

10 The cut muscle ends should fall apart and the mucosa and sub-mucosa should bulge into the whole length of the wound. Any attempt to separate them further by gauze dissection usually tears open the mucosa. Should the accident occur the opening should be sewn up transversely as in Mikulicz pyloroplasty.

SPECIAL POST-OPERATIVE CARE

Gastro duodenostomy and open pyloroplasty

The post-operative management of the patient is the same as for gastro-jejunostomy.

Pyloromyotomy

No special post-operative care is required, but a soft diet is recommended for 3 or 4 days.

[The illustrations for this Chapter on Gastro-duodenostomy, Pyloroplasty and Pyloromyotomy were drawn by Miss H Wilson.]

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DUODENO-JEJUNOSTOMY

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PRE-OPERATIVE

Diagnosis of neonatal duodenal obstruction

The time of onset of symptoms depends on the severity of the obstruction—immediately after birth in atresia and almost complete obstructions later in infancy in the less complete lesions. As most congenital obstructions of the duodenum lie distal to the ampulla of Vater the vomiting is usually bilious in contrast to that in pyloric stenosis the symptoms of which begin usually about the third week of life and become progressively more severe

Plain radiograms are diagnostic in complete and almost complete obstructions. Barium is avoided because of the risk of aspiration in the newly-born baby but it may be necessary in the diagnosis of incomplete lesions. It should be given by gavage.

Duodenal atresia and stenosis may be associated with other congenital anomalies, one of the more frequent being mongolism.

Extrinsic duodenal obstruction is considered under the heading of neonatal obstructions.

Indications

Duodeno-jejunostomy is indicated in congenital atresia or stenosis of the duodenum distal to the ampulla of Vater in the case of annular pancreas causing duodenal obstruction in the newborn and in congenital atresia of the highest jejunal loop when jejuno-jejunostomy is impracticable Ileus of the duodenum is also an indication.

Special contra-indications

Gastro-jejunostomy is the best procedure in congenital atresia of the duodenum above the ampulla of Vater which is, however relatively rare

Special equipment

No special equipment is required except for small instruments and very fine atraumatic silk and catgut sutures.

Pre-operative preparation

The stomach is aspirated and the tube is left in position for continuous aspiration.

Dehydration is corrected by intravenous therapy and blood is cross matched in readiness to be given during the operation.

Anaesthesia

Endotracheal cyclopropane and oxygen, gas, oxygen and ether or open ether with or without a relaxant are used.

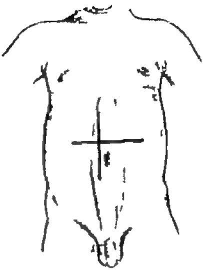
Position of patient

The baby lies in the supine position, the transfusion is maintained by the introduction of a polythene tube or cannula into the great saphenous vein on the same side as the surgeon to allow adequate space for the assistant and theatre sister on the opposite side

THE OPERATION

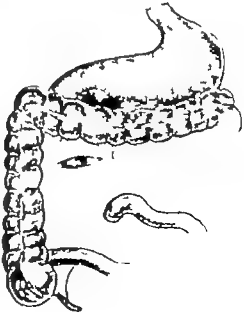
The incision and exposure

1 A right paramedian muscle cutting or muscle displacing incision or an upper transverse incision giving generous access is used.
The small contracted upper jejunum confirms that the obstruction is above the duodeno-jejunal flexure. When the transverse colon is lifted upwards and forwards the distended duodenum may be visible through the transverse mesocolon. If the caecum is not in its normal site but is lying in the sub-hepatic position the peritoneum lateral to it is divided and the right colon and hepatic flexure are displaced to the left to expose the duodenum to establish whether the obstruction of the duodenum is extrinsic or intrinsic. Having established that the obstruction is intrinsic or due to annular pancreas, duodeno-jejunostomy is the operation of choice. The remainder of the small bowel is examined to exclude the presence of other atresias.



Incision of the mesocolon

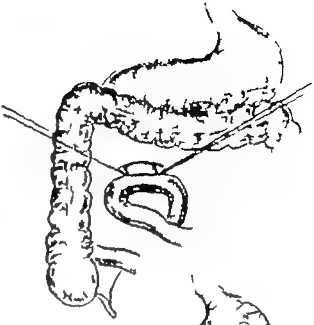
2 An opening is made in the transverse mesocolon to the right of the middle colic vessels. If the duodenum is grossly distended it is wise to aspirate it before handling it. A suitable part of the duodenum is brought through *the opening in the mesocolon and the first* part of the jejunum is brought into apposition with it so that an isoperistaltic anastomosis can be made



Apposing the jejunum and duodenum

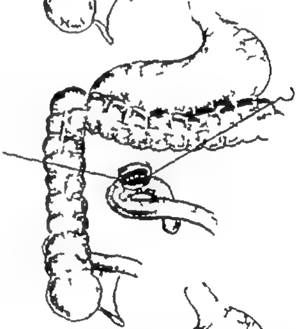
3 The jejunum distal to a complete obstruction is of such small calibre for anastomosis that it is advisable to distend it by the injection of a few millilitres of saline and air or liquid paraffin and air. Having established that the jejunal loop will lie in apposition to the duodenal one without kinking, stay sutures are inserted at either side of the line of the proposed lateral anastomosis.

The posterior seromuscular stitch is inserted either with interrupted sutures of fine silk or with a continuous suture of the same material, care being taken not to pull the continuous stitch too tightly. The sutures should be mounted on the finest and smallest atraumatic needles.



Suture of the posterior layers

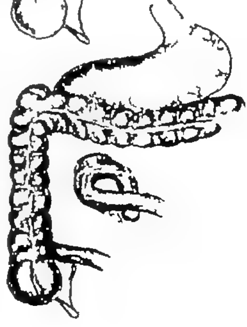
4 *The duodenal and jejunal loops are opened* close to the suture line and are carefully cleansed and emptied. The posterior mucosa-to-mucosa stitch is of the finest catgut on a small atraumatic needle. When this stitch is completed it is tied and may then be continued as the anterior mucosal suture.



Suture of the anterior layers

5 The first anterior stitch invaginates the edges, great care being taken not to take too big a bite of tissue, for there is little to spare on the jejunal side. The anastomosis is completed by the insertion of an anterior seromuscular stitch either of continuous or interrupted silk.

The opening in the mesocolon is stitched to the duodenal side of the anastomosis and the abdominal incision is then closed.



Alternative procedure

If the jejunal loop does not lie nicely an anterior duodeno-jejunostomy may be made instead of the posterior one described here.

POST-OPERATIVE CARE AND COMPLICATIONS

The baby is returned to an incubator suitable for the administration of oxygen and with controlled humidity or to a suitably equipped neonatal ward.

Gastric suction

Gastric suction is continued until bile is no longer obtained.

Transfusions

Blood transfusion is continued until the blood loss at operation no matter how small is made good and a further 10 ml. per pound of body weight may also be given with safety

Antibiotic therapy

Antibiotic therapy is given to try to prevent the common respiratory complications.

Use of saline enemas

The contracted bowel distal to the obstruction does not open up without time and effort. The opening up of the large bowel is assisted by the twice daily administration of saline enemas.

Nutrition

Feeding must not be begun until it is obvious from the small amount of gastric aspiration that the gastric and duodenal secretions are passing onwards. As this may take several days the baby must be maintained by the parenteral administration of fluids and electrolytes.

A careful check is kept on the plasma proteins and the haemoglobin during the post-operative period and any deficiency is made good by plasma or blood transfusion.

As soon as the gastric aspiration has practically ceased the first feed of not more than ½-ounce is given. The stomach is aspirated 3–4 hours later and if there is no sign of retention of the feed in the stomach another feed is given. The feeds are built up very slowly and vomiting should be avoided because of the danger of aspiration of vomitus in small ill babies.

Complications

There is a definite association between duodenal atresia and mongolism. While it may be obvious that the baby is a mongol the diagnosis of this condition in the newly born is often very difficult. If the diagnosis of mongolism is made the question of operation for the duodenal obstruction requires careful consideration. If mongolism develops at a later stage it is not in any way related to the operation of duodeno-jejunostomy

[The illustrations for this Chapter on Duodeno-jejunostomy were drawn by Mr J Wheldon]

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GASTRO-JEJUNOSTOMY AND ANTRAL-EXCLUSION

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PRE-OPERATIVE

Indications

Pyloric stenosis due to an old, healed duodenal ulcer in a frail patient is an indication for gastro-jejunostomy. Stomal ulcer is a not infrequent sequel, but this risk may have to be accepted to avoid a greater one.

Other indications are pyloric or duodenal obstruction due to scar tissue following wounds or severe perigastric inflammation, or pressure from inoperable growths of adjacent organs such as pancreas, bile ducts and kidney.

For irremovable duodenal ulcer, gastro-jejunostomy plus vagotomy is no less successful than gastrectomy with preservation of a piece of antrum, and much safer than Bancroft's procedure of coring out the antral mucosa. The combination may also be considered for an intractable ulcer in a patient who is unfit for gastrectomy. Some surgeons favour it as well when the patient is very young or very thin.

Unobstructed but irremovable cancer of the gastric antrum may be dealt with by antral-exclusion, for this may improve the patient's general condition by reducing digestion and infection of the growth. For obstructing non-resectable tumours, anterior gastro-jejunostomy may be all that is possible, but it seldom does much good.

In congenital duodenal atresia above the ampulla of Vater, anterior gastro-jejunostomy is advised. Below this level, duodeno-jejunostomy should be used.

Contra-indications

Gastric retention causes free hydrochloric acid to disappear from the stomach. A high level of total acidity indicates hypersecretion and contra-indicates gastro-jejunostomy, or at least requires the addition of vagotomy.

Pyloric obstruction is often complicated by a gastric ulcer. Though this makes gastrectomy more desirable, it does not absolutely contra-indicate gastro-jejunostomy in a patient who is a bad surgical risk, for gastric retention has been the cause of such an ulcer and it may heal when the retention is relieved (Johnson, 1955).

Antral-exclusion must not be used when pyloric obstruction is present or imminent, lest retained secretions burst the suture line.

Duodenal ileus is not an indication for gastro-jejunostomy, duodeno-jejunostomy being then required.

Pre-operative preparation

Surgery should never be precipitate in chronic pyloric obstruction. The oedema and spasm which commonly exaggerate organic stenosis will subside a little with saline gastric lavage, antacids, anti-spasmodics and a high-protein, high-calorie fluid diet.

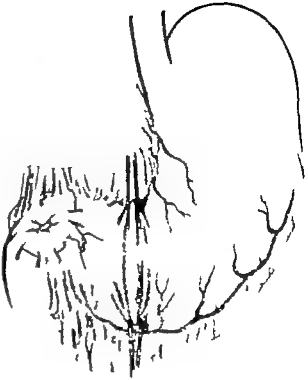
Dehydration, alkalosis and hypoproteinaemia should be corrected before operation, if necessary by rectal and intravenous routes, and a blood transfusion is often needed. The severe constipation should be controlled with enemas and the teeming bacterial population of an achlorhydric stomach should be reduced with oral streptomycin or penicillin. If a patient with carcinoma of the stomach has any hope of being salvaged by operation then he is worth preparing properly for the attempt in the same way, though it is reasonable to withhold blood transfusion until laparotomy has shown that something can indeed be done.

A size 6 (E) Jacques or Levin's gastric tube should be passed when the premedication is given.

THE OPERATION

The incision

Gastro-enterostomy being an operation required usually in elderly frail patients, a time-saving mid-line incision is often used. Otherwise an upper left paramedian is chosen. Posterior short-loop gastro-enterostomy will be described first.



POSTERIOR, SHORT-LOOP GASTRO-ENTEROSTOMY

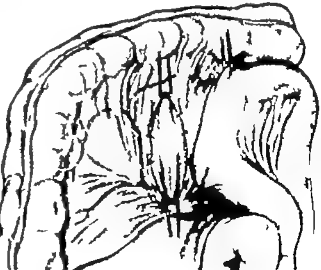
Placing of the stoma

1 If an anterior duodenal ulcer is present it is wise to bury it with a purse-string suture. The stoma is placed vertically and its lower end should be exactly at the most dependent point on the greater curvature. This point and the one vertically opposite to it on the lesser curve are marked with Babcock or Allis forceps.

Attachment of the stomach to the mesocolon

2 The transverse colon is lifted and held up by the assistant. This will cause the stomach to fold over so that the greater curve is above the lesser A bloodless area is sought in the mesocolon to the left of the middle colic vessels and a window made in it 3 inches long The posterior wall of the stomach is made to present through this window the noses of the two marker forceps lying at top and bottom ends. The mesocolon is sewn to the stomach with interrupted sutures and the marker forceps removed.

The duodeno-jejunal flexure is located and a segment of bowel selected 8 inches in length and about 4 inches beyond the flexure. This is laid beside the gastric segment, proximal end to lesser curve



3

Gastro jejunal apposition and suture

The top ends of stomach and jejunum are united by a stay suture (1) as near as possible to the greater curvature and a continuous, sero-muscular suture (2) is begun at the lower end. This may be of catgut or non-absorbable material such as No 1 silk. The latter may be considered more suitable for elderly wasted patients who are likely to be slow to heal.

The assistant picks up and holds taut the stay suture (1) and the tail of the sero-muscular suture (2) while this is completed. The sero-muscular suture is knotted to the stay suture and then laid aside.

4

Incision through the gastric serous and muscular coats

An incision is made through the serous and muscle coats of the stomach 0·6 cm. away from the suture line and finishing 0·6 cm shorter than it at each end, the vessels of the sub-mucosa being thus exposed. Each is twice under-run and tied off. It is not usually considered necessary to do the same on the jejunal side.

Opening of the stomach and jejunum, and posterior suture

5 Stomach and jejunum are now opened 0·5 cm. from the sero-muscular suture line, the openings terminating 0·5 cm. shorter than the latter at each end.

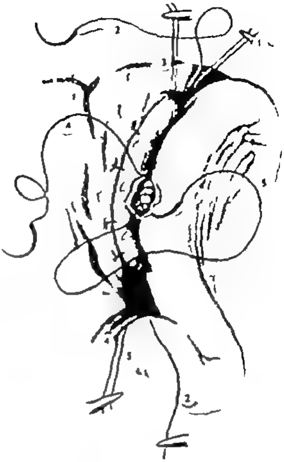
An all-coats stay suture of catgut (B) unites the top angle of the two openings and two No 00 or No 000 catgut sutures on atraumatic needles (4 and 5) are begun and tied together at the bottom angle, one being laid aside.

The assistant now picks up and holds taut the all-coats stay suture (B) and the tails of the two catgut, all-coats sutures (4 and 5) while the posterior over-and-over all-coats layer is completed.

Suture of the anterior aspect

The uppermost angle

6 The first all-coats suture having reached the top angle is tied to the all-coats stay suture and then begins the anterior layer. Again a simple over-and-over method is used but each bite is pulled tight as the suture comes out on the mucosal surface, a finger being pressed on the outside of the completed suture line as this is done. This will be found to effect the desired inversion of the bowel edges.



7

The lower angle

This first all-coats suture (4) stops when it reaches the middle of the stoma and as it emerges on a serosal surface

The second all-coats suture (5) now unites the bowel and stomach from the lower angle upwards until it meets the first at the middle of the stoma. It is likewise made to emerge on a serosal surface and the two are tied together

8

Completion of the anastomosis

The all-coats stay suture and both all-coats sutures are now cut short.

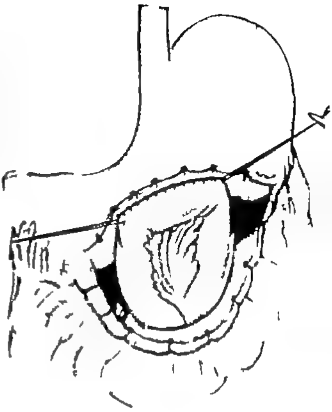
The assistant picks up again the sero-muscular stay suture (1) and the tail of the sero-muscular suture (2) and holds these taut while the anterior sero-muscular layer of Lembert stitches is inserted and completed

Alternative procedure

Passing the jejunum through the mesocolon

9 An alternative method of performing posterior gastro-enterostomy useful when the stomach is high and its posterior wall cannot be reached satisfactorily from below the mesocolon. Some surgeons prefer this as a routine method. The great omentum is removed from the most dependent 5 or 6 inches of the greater curvature, keeping close to the stomach. A 3 inch window is made in the mesocolon, from below to the left of the middle colic artery and a loop of jejunum is passed through it. The greater curvature of the stomach is turned upwards to show its posterior surface (those who use gastro-enterostomy clamps will apply them at this stage) A 3 inch segment of jejunum, with an afferent loop of a length which neither sags nor drags, is now anastomosed to the posterior wall of the stomach, parallel and as close as possible to the lowest part of the greater curve.

The steps in the anastomosis are as described for the standard method.



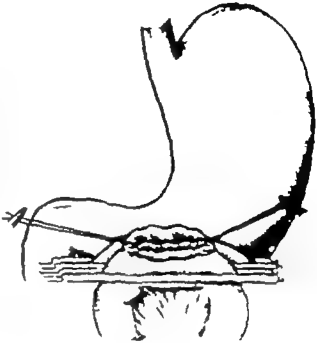
Fixation of the mesocolon to the stomach wall

10 Finally the colon is lifted and held up The anastomosis is made to present at the window in the mesocolon and the edges of the opening are sutured to the walls of the stomach.

This position for the stoma is particularly recommended when gastro-enterostomy is combined with vagotomy and a right-to-left direction for the jejunal loop has been said to be the most successful (Crile, 1951)

Use of gastro enterostomy clamps

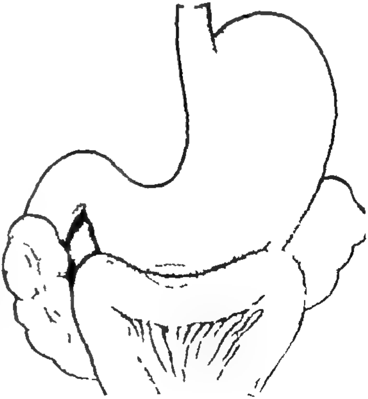
11 All methods may be performed, if preferred, with gastro-enterostomy clamps. They make the operations quicker and easier but many surgeons prefer not to traumatize the bowel even to this extent. Moreover it is held by many that haemorrhage can be seen and more certainly controlled when clamps have not been used.



ANTERIOR GASTRO-ENTEROSTOMY

Principles of the operation

12 The jejunal loop has been brought in front of the transverse colon and is often found to be more easily taken from left to right. This method necessitates a longer afferent loop of jejunum, is subject to more hazards than the posterior method and does not drain the stomach so well but it may have to be resorted to when the mesocolon is very short, when the lesser sac is obliterated by adhesions, or in an infant. It is wise to resect most of the omentum and it is often still possible to turn up the greater curve of the stomach and make *the stoma* on the back of the most dependent part.



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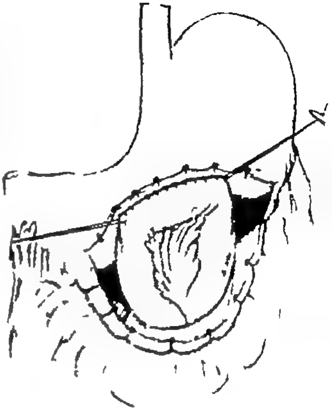

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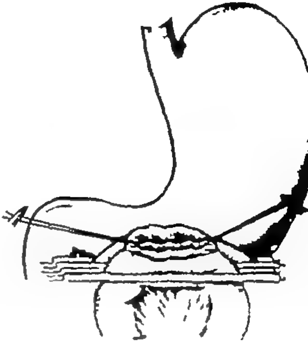

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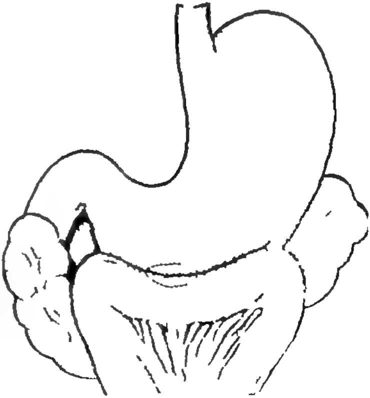

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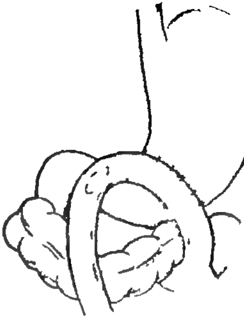
Juxta pyloric position

13 A method of performing anterior gastro-enterostomy recently introduced by Tanner (1951) The stoma is juxta-pyloric and in this region the gastric mucosa secretes an alkaline juice. If a stomal ulcer develops, this kind of gastro-enterostomy is the easiest to undo leaving a clean field for gastrectomy Tanner advises the suturing of a curtain of omentum to the stomach in front of the anastomosis and afferent jejunal loop.



Antral-exclusion for fixed carcinoma of the antrum

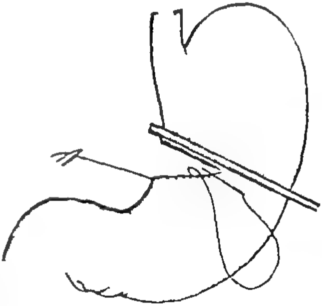
Separation of the antrum

14 The omentum is separated from the stomach as for gastrectomy starting to the left of the growth and as far as the lower pole of the spleen.

A crushing clamp is applied across the stomach, a good 2 inches clear of the lesion, but not sacrificing more gastric capacity than is necessary

A No 0 catgut suture on a straight atraumatic needle is begun on the lesser curve ¼ inch below the clamp

The antrum is now cut off below the clamp and oversewn ¼-inch at a time. Good tension is maintained on the tail of the suture by the operator until it is complete, to control haemorrhage and prevent pouting of mucosa.



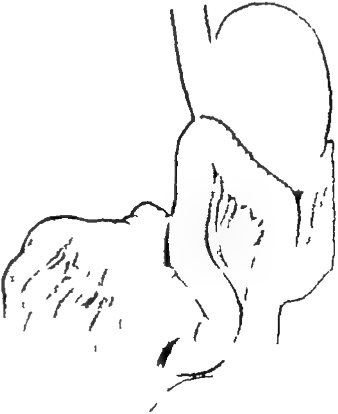
Closure of the antrum

15 A stay suture of No 1 silk inserted as a purse string (1) invaginates the greater curvature corner of the last suture line and a continuous sero-muscular layer of No 1 silk (2) starts similarly as a purse string at the lesser curve end. The tail of this suture and the stay suture are held apart by the assistant while the sero-muscular layer is completed. (The purse string suture is also shown ready for tying (8) to illustrate the method of placing it.)

Anastomosis of jejunum and proximal pouch of stomach

16 After closure of the lesser curve half of the proximal pouch of stomach, a loop of jejunum is now brought up in front of the colon and anastomosed to the stomach, exactly as in Polya gastrectomy

Finally omentum is well wrapped around the closed off antral stump to contain, as far as possible, future spread of the neoplasm. Drainage is a wise precaution after this operation.



POST-OPERATIVE CARE AND COMPLICATIONS

Continuous gastric suction is maintained until bowel sounds are heard. During this time small drinks of water are allowed as desired, and an adequate fluid balance is maintained by rectal or intravenous drip infusion.

As soon as bowel peristalsis returns, hourly gastric emptying followed by a 5 oz. feed of peptonized milk is substituted.

When the total volume of fluid aspirated during the past 4 hours is down to half, or less, that given by mouth during the same period, gastric suction is discontinued, and the hourly feed may be increased to up to 8 oz. of milk, fortified with dried milk powder cream, and eggs. A light diet is allowed when the bowels have been open.

Haemorrhage

Post-operative haemorrhage may be either from the suture line or from the ulcer The former occurs within 48 hours of operation. It is less likely if no clamps are used and implies insufficiently firm and careful suturing If clamps are employed, they should be loosened after completion of each row of through-and-through sutures, so that bleeders may be seen and under-run. Infolding of the ulcer by a Mayo-Kelling suture reduces the chance of its subsequently bleeding or perforating The treatment of post-operative haemorrhage is initially by blood transfusion, but for severe bleeding which persists the wound must be re-opened, the anterior wall of the stomach incised and the bleeding point found and oversewn.

Obstruction

Vomiting or continued aspiration of large quantities of bile and gastric juice after the return of bowel sounds usually indicates obstruction to one or other loop of jejunum by kinking, compression or herniation through a mesocolic aperture the edges of which have not been sufficiently firmly sutured to the stomach. Rarer causes are obstruction at the stoma by oedema prolapsed mucous membrane and jejuno-gastric intussusception

Gastric lavage with full intravenous replacement of lost water and chlorides is first tried. If re-operation has to be undertaken, the temptation to perform entero-anastomosis must be resisted. If the cause cannot be rectified in any other way the anastomosis may have to be taken down and remade. If the patient is not fit for this, or no apparent cause is found, jejunostomy should be performed using two tubes, one led up through the stoma into the stomach, the other led down into the bowel. After bowel sounds have returned what is withdrawn from the upper tube may be cautiously replaced into the lower tube

Peritonitis

Vomiting may also herald the onset of peritonitis due to breakdown of the suture line or perforation of the ulcer and these will necessitate re-operation.

Gastro-jejunal ulcer

This is a frequent late complication of gastro-jejunostomy particularly when some procedure, such as anastomosis of the afferent and efferent loops or the use of Roux s Y method, has prevented free bathing of the stoma by pancreatic juice and bile.

The addition of vagotomy to gastro-enterostomy considerably reduces the incidence of the complication.

[The illustrations for this Chapter on Gastro-jejunostomy and Antral-exclusion were drawn by Miss H Wilson.]

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PARTIAL GASTRECTOMY

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PRE-OPERATIVE

Indications

For the elective treatment of chronic gastric, duodenal, stomal and rarely oesophageal ulcer For urgent complications of ulcer for example haemorrhage, perforation and stenosis.

For simple tumours of the stomach Not every simple tumour need be removed, e g small lipomata or islets of accessory pancreatic tissue are best left undisturbed. Resection is required if the tumour is liable to ulcerate or bleed (e.g leiomyoma, neurilemmoma) or is bulky or pedunculated and causes colic and vomiting by being propelled into the duodenum, or has malignant potentialities (e.g. multiple adenomatous polyps) or is difficult to differentiate from a malignant tumour (leiomyoma)

Gastrectomy is rarely indicated for infective lesions, e.g. tuberculosis. Other rare indications are gastric strangulation or recurrent gastric volvulus, or extensive stenotic lesions.

The gastro-duodenal reconstruction (Billroth I) is more physiological and is used for most cases of gastric ulcer Where the duodenum is damaged or has to be widely excised (for example carcinoma) or where the stomal ulcer tendency is high as in cases of active duodenal or stomach ulcers, then a gastro-jejunal anastomosis (Polya, Balfour) is usually more satisfactory

Pre-operative preparation

Severe anaemia must be corrected. In non-urgent cases a few days in bed will reduce the inflammation around an ulcer and facilitate suturing of the bowel near the ulcer It will also give time to correct starvation and vitamin deficiencies, and to give the physiotherapist an opportunity to teach the patient respiratory exercises. Smoking is to be avoided in the week preceding operation.

A course of gastric lavage with saline and parenteral fluid will be of help in cases with duodenal stenosis. It is an advantage to evacuate the stomach just before the patient goes to sleep at night, so that the stomach may resume its normal size and tone during the night hours.

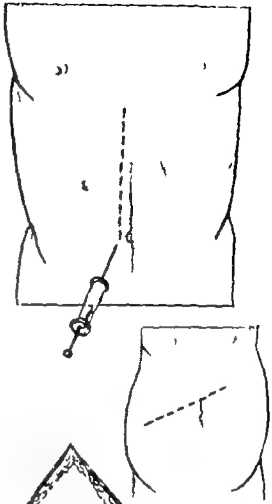
Anaesthesia

General anaesthesia using an endotracheal tube is satisfactory Where general anaesthesia is contra-indicated the operation may be carried out under local anaesthesia. It is useful for the anaesthetist to be able to empty the stomach from time to time, and so a naso-gastric tube should be in place prior to operation

Position of patient

The dorsal position is used. One or both arms may be fixed at right angles to the body if the anaesthetist requires access to the veins.

THE OPERATION



The Incision

1 A right upper paramedian incision is usually employed. This should extend from the xiphisternum to the level of the umbilicus or just below. It is of help to infiltrate the line of incision with a solution of 1 : 8 000 amethocaine with 1 : 200 000 adrenaline. In obese patients with duodenal ulcer a transverse incision facilitates exposure of the duodenum. This incision should be at about 15 degrees to the horizontal, extending from the left costal margin opposite the ninth costal cartilage to just below the right costal margin in the anterior axillary line.

General exposure and exploration

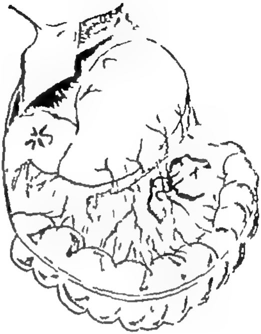
2 After opening the peritoneal cavity the ligamentum teres is divided between ligatures close to the liver. The stomach and duodenum are then carefully examined to define the site and extent of ulceration. Any anterior adhesions to the ulcer may be divided at this time. A general abdominal exploration is carried out to ascertain whether any other lesion is present.

VALVED "BALFOUR" GASTRECTOMY FOR DUODENAL ULCER

Preliminary mobilization of the stomach

Division of the gastro-colic omentum

3 The lesser sac of peritoneum is opened by breaking through an avascular area in the gastro-colic omentum outside the gastro-epiploic arch and well to the left. The gastro-colic omentum is then divided between ligatures in small segments working from left to right, so that all the epiploic branches of the gastro-epiploic arch are ligated. The left gastro-epiploic artery may be ligated at this stage or later. In very obese patients excision of most of the great omentum will eliminate the risk of post-operative necrosis.



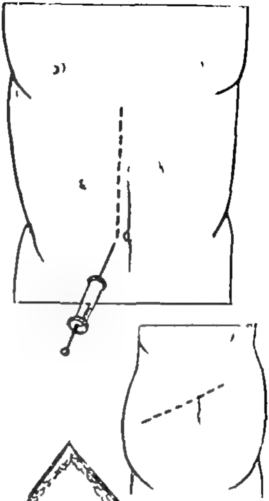
Separation of the mesocolon

4 Adhesions between the posterior wall of the stomach and the mesocolon are divided and the mesocolon is swept downwards by gauze dissection, particular care being taken to separate the middle colic vessels from the right gastro-epiploic vessels, to which they normally lie in close proximity. At times sharp dissection with the scissors or scalpel is required. The dissection is carried to the right until the posterior wall of the duodenum comes into view. In most cases some adhesion between the pancreas and duodenum will then be encountered, but if the posterior duodenal wall is healthy the separation may be continued until the gastro-duodenal artery comes into view on the anterior surface of the pancreas.

THE OPERATION

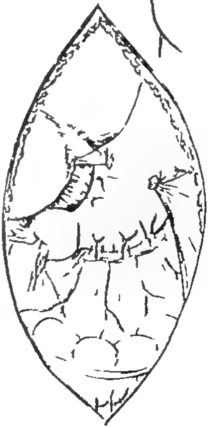
The incision

1 A right upper paramedian incision is usually employed. This should extend from the xiphisternum to the level of the umbilicus or just below. It is of help to infiltrate the line of incision with a solution of 1 : 2 000 amethocaine with 1 : 200 000 adrenaline. In obese patients with duodenal ulcer a transverse incision facilitates exposure of the duodenum. This incision should be at about 15 degrees to the horizontal, extending from the left costal margin opposite the ninth costal cartilage to just below the right costal margin in the anterior axillary line.



General exposure and exploration

2 After opening the peritoneal cavity the ligamentum teres is divided between ligatures close to the liver. The stomach and duodenum are then carefully examined to define the site and extent of ulceration. Any anterior adhesions to the ulcer may be divided at this time. A general abdominal exploration is carried out to ascertain whether any other lesion is present.

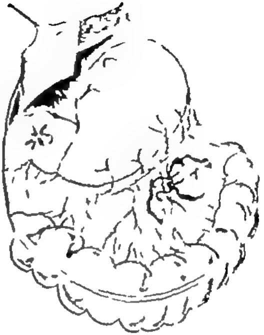


VALVED "BALFOUR" GASTRECTOMY FOR DUODENAL ULCER

Preliminary mobilization of the stomach

Division of the gastro-colic omentum

3 The lesser sac of peritoneum is opened by breaking through an avascular area in the gastro-colic omentum outside the gastro-epiploic arch and well to the left. The gastro-colic omentum is then divided between ligatures in small segments working from left to right, so that all the epiploic branches of the gastro-epiploic arch are ligated. The left gastro-epiploic artery may be ligated at this stage or later. In very obese patients excision of most of the great omentum will eliminate the risk of post-operative necrosis.



Separation of the mesocolon

4 Adhesions between the posterior wall of the stomach and the mesocolon are divided and the mesocolon is swept downwards by gauze dissection, particular care being taken to separate the middle colic vessels from the right gastro-epiploic vessels to which they normally lie in close proximity. At times sharp dissection with the scissors or scalpel is required. The dissection is carried to the right until the posterior wall of the duodenum comes into view. In most cases some adhesion between the pancreas and duodenum will then be encountered, but if the posterior duodenal wall is healthy the separation may be continued until the gastro-duodenal artery comes into view on the anterior surface of the pancreas.

Mobilization of the duodenum

Division of the right gastro-epiploic pedicle

5 The right gastro-epiploic pedicle is displayed under slight tension by drawing the pyloric region forward, and then divided between ligatures. No advantage is gained, in a case of simple ulcer by taking the vessels individually or near their origin, or by dissecting and removing glands the pedicle is therefore divided close to the pylorus.

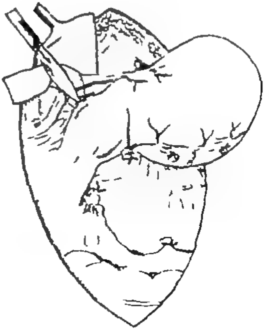
The inferior border of the duodenum is now dissected clean to a point 0 5–1 cm beyond the proposed line of transection, by placing fine artery forceps on the small vessels entering the duodenum in very close approximation to the duodenal wall, and dividing the vessels with a scalpel between the duodenum and the forceps. The vessels are then ligated with fine thread.

The posterior wall of the duodenum is cleaned in a similar manner

Exposure of the right gastric pedicle

6 The tenuous hepato-gastric ligament is slightly stretched by drawing the duodenum forward and downward, and a finger is passed through it.

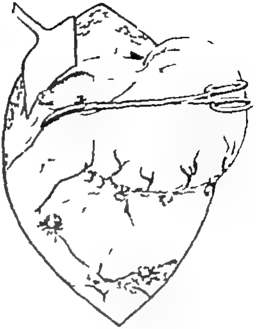
The superior border of the duodenum, which may be deformed by ulceration or scarring, is outlined over a short distance near the pylorus by incision of the peritoneum and of any scar tissue between the duodenal border and the gastro-hepatic omentum.



Division of the right gastric pedicle

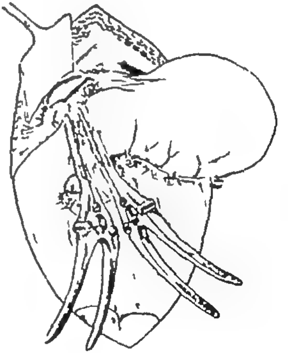
7 The right gastric vessels now lie between the hole in the hepato-gastric omentum and the incision along the superior border of the duodenum they are here divided between ligatures without individual dissection.

The superior border of the duodenum is cleaned in a similar manner to that described for the inferior border If a superior ulcer or scarring or diverticulum-formation is present, this method of dissection enables the superior border to be defined with a minimum of danger to the common bile duct.



Transection of the duodenum

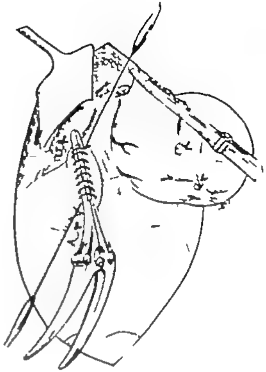
8 The duodenum is transected between Payr s clamps. The line of transection is as close to the pylorus as the ulcer deformity will allow Every millimetre of healthy duodenum possible is preserved this often involves crushing a duodenal ulcer with the proximal clamp and so spoiling the pathological specimen, but as carcinoma does not arise in the duodenum, microscopic examination is of academic interest only The line of transection must be distal to the narrowing caused by the duodenal scarring, or it will be difficult to invert the closed end later on. In some cases however it is helpful to transect the duodenum before dissection is complete, then complete the mobilization of its posterior wall after the pylorus and stomach have been drawn over to the left.



Closure of the duodenum

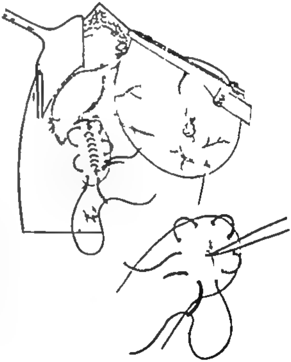
The all-coats layer

9 A linen suture is inserted and knotted under the point of the distal Payr's clamp. A continuous over-and-over stitch is put in loosely over the clamp which is then removed and the suture pulled up tight, a loop at a time and knotted with a final stitch. By this means both haemostasis and firm closure are secured. The Payr clamp can usually be relied on to seal together the crushed duodenal edges and leakage does not usually occur when it is removed. If a lighter crushing clamp is used, one should be prepared for possible soiling with duodenal juice, by having a gauze pack round the area, and a "sucker" to hand.



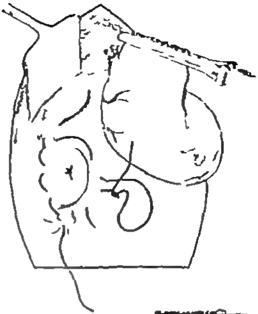
The sero-muscular layers

10 The closed duodenal stump is invaginated by means of a sero-muscular purse-string suture with thread. This suture commences on the posterior wall of the duodenum, passes round the superior, anterior and inferior walls to end posteriorly. As it is tightened the closed stump is invaginated. A second sero-muscular purse-string suture is inserted to invaginate the first one. This stitch commences and ends on the anterior wall of the duodenum (inset). It is safe to use non-absorbable continuous stitches in closing the duodenal stump because this area does not normally come in contact with gastric juice. Continuous non-absorbable sutures on a gastric suture line, however, may lead to trouble (Tanner 1951). If desired, fine chromic catgut may be used instead of linen to close the duodenum.



Final suture

11 As a final safeguard a stitch is placed successively through the right gastro-epiploic pedicle the anterior duodenal wall, the right gastric pedicle the peritoneum or scar tissue over the pancreas adjacent to the duodenal stump and finally back through the right gastro-epiploic pedicle. When this suture is drawn tight the pedicles are drawn together and the duodenal stump snugly buried



Mobilization of the lesser curve of stomach

Exposure of the left gastric pedicle

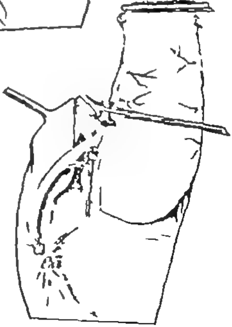
12 The stomach is held forward and the lesser omentum is palpated for the presence of an accessory hepatic artery If none is present this omentum is divided for 2–3 inches. Not infrequently a fairly large accessary hepatic artery is found running in the lesser omentum from the left gastric artery to the porta hepatis if present, such a vessel should be preserved.

Any adhesions in the lesser sac between the pancreas and posterior wall of stomach are now divided and the stomach lifted upwards. The left gastric vein can be seen lying in the free edge of the falx coronarium.

Division of the left gastric pedicle

13 The edge of the lesser curve is palpated between finger and thumb at a level approximately opposite the division of the left gastric artery into ascending and descending branches. The whole pedicle is ligated at this level close to the stomach wall using an aneurysm needle it is then divided between artery forceps and the proximal end ligated for a second time.

The lesser curve is cleaned for 2–3 cm. below this point by gently stripping downwards the distal ligated part of the left gastric vessels, securing any small vessels passing to the stomach wall.



Mobilization of the greater curve of stomach

Exposure and division of the short gastric vessels

14 The stomach and colon are held forward and the gastro-splenic ligament is inspected from the posterior or lesser sac aspect. The short gastric vessels are seen well by this approach the lower two or three are divided between ligatures, after division of the left gastro-epiploic artery if this has not already been taken. It is helpful to have the upper part of the stomach emptied by the anaesthetist during this stage.

The site of gastric transection is selected and the greater curve cleaned over 2–3 cm. at this level

The antecolic gastro-jejunal anastomosis with valve

The posterior sero-muscular layer

15 The first of (Lane's) twin clamps is applied across the stomach at the level selected.

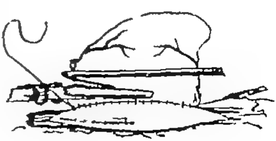
The proximal loop of jejunum is held up with the afferent loop above (towards the lesser curve) and the second clamp applied from a point not more than 3–4 inches from the duodeno-jejunal flexure. The clamps are fixed together

The posterior sero-muscular suture of catgut is commenced at the lower end where it is knotted and continued to the upper end. Here a hitch-knot temporarily secures it.

Formation of the valve

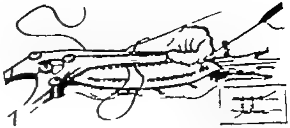
16 A Payr's clamp is applied to the lesser curve side across half to two-thirds of the stomach. A soft clamp is applied a little distally to avoid spillage of gastric contents on transection.

The stomach is transected by cutting close to the Payr's clamp. On the greater curve side the gastric stoma is formed by incising the posterior wall of the stomach ¼ inch from the sero-muscular suture and carrying the incision round the anterior wall at a level a little more distally. The specimen is removed.



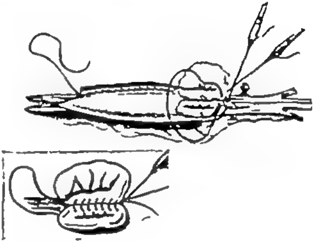
Closure of the valve

17 The valve is closed under a Payr's clamp by means of a continuous catgut "sewing machine" stitch, commencing on the lesser curve. Special attention must be paid to avoid any slackening of the suture during insertion



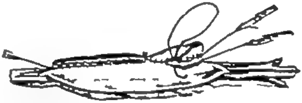
The posterior all-coats layer

18 The jejunum is incised directly opposite the open part of the stomach, also ¼ inch from the sero-muscular suture The continuous all-coats layer commences at the lower end with a knot on the serosa, the catgut is passed back through the wall to the mucosal surface, and a series of fairly small over-and-over stitches are inserted, care being taken that mucosa, muscularis, and serosa are included in each stitch.



The anterior all-coats layer

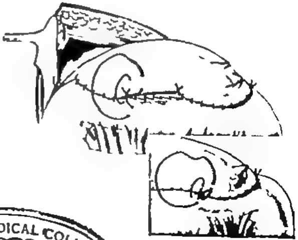
19 The corner is turned by means of a single Connell stitch which brings the catgut to the serous surface of the jejunum. The over-and over stitch is continued to the lower end, the mucosa being gently invaginated as each stitch, passing from serosal to mucosal surface of the stomach, is pulled tight. The Lane's clamps are removed.



The anterior sero-muscular layer

20 The posterior Lembert stitch is continued down the anterior surface of the valve using broad stitches to flatten out the jejunum and thus increase the efficiency of the valve.

When the level of the stoma is reached, small stitches are employed and continued until they join the commencement of the posterior layer



The anastomosis completed

21 A final stitch is inserted at the upper angle of the anastomosis taking the sero-muscular coat of the afferent jejunal loop, and the sero-muscular coat of the posterior surface and of the anterior surface of the stomach on each side of the bare lesser curve. This bare area is thus covered and additional support given to the afferent loop If the afferent loop appears to be too long, it may be tacked higher up the lesser curve of the stomach by further stitches. Additional reinforcing sutures may be inserted if any part of the suture line appears to require it.

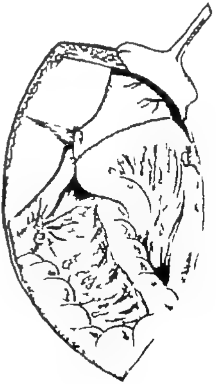
Final placement and inspection

22 The colon is drawn through as far as possible to the right, so that its weight shall not hang on the afferent jejunal loop and the colon lying above the afferent loop is supported by the left phreno-colic ligament. When the stomach and jejunum are returned into the abdominal cavity the line of anastomosis is seen to be lying in a transverse position.

Before closing the abdomen the splenic region, the vascular pedicles and the omenta are inspected for possible bleeding

The upper vasa brevia are best inspected by lifting the stomach remnant forwards with a deep retractor when the whole of the upper lesser sac comes into view

Finally any blood or fluid is aspirated from the retrosplenic region, the right suprarenal fossa and any other collection gently mopped up



The retrocolic gastro-jejunal anastomosis

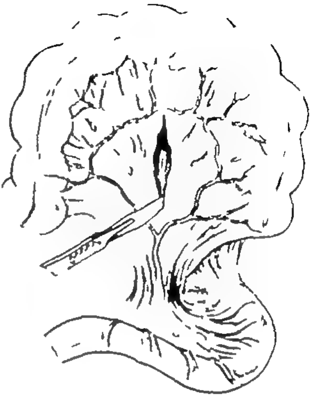
The stomach is mobilized and prepared for transection, as in Illustrations 8–14

Incision of the mesocolon

23 The transverse colon is lifted up and the mesocolon inspected It is incised through an avascular area for about 2 inches in a radial direction.

Generally speaking this opening should be rather towards the left, and in as mobile a part of the mesocolon as is available Rarely a transverse incision will be more practical, bearing in mind that the opening made will subsequently surround the upper stomach.

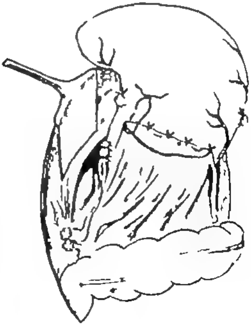
At times the mesocolon is very fatty scarred, well vascularized, short or even absent. In such cases an antecolic reconstruction is preferable.



Posterior attachment of mesocolon to stomach

24 After drawing the stomach forwards, the mesocolon is attached to its posterior wall 1 inch or so above the proposed line of transection by a series of interrupted thread sutures. The least mobile part of the mesocolon, near the root, is attached to the least mobile (lesser curve) region of the stomach.

No hard and fast rule need be laid down, however and if the mesocolon is very mobile it is quite satisfactory to attach the part of the opening nearest the stomach to the posterior wall as it lies most conveniently Care must be taken to avoid damaging mesenteric vessels with the sutures.



Application of the clamps and anastomosis

25 The proximal jejunal loop is drawn through the hole in the mesocolon, the twin clamps are applied leaving a short afferent loop of jejunum leading to the lesser curve, and the anastomosis proceeds as described in Illustrations 15–21

In some cases it may be desired to bring the afferent jejunal loop to the greater curve of the stomach, and the efferent to the lesser curve This will provide a satisfactory gastrectomy but in such cases the valve should be made short, or on the greater curve side of the stomach, or the efferent loop should not be stitched too high up the lesser curve side of the stomach, or obstruction to gastric evacuation may result.

Anterior attachment of mesocolon to stomach

26 The jejunum is drawn back through the mesocolon so that the anastomosis now lies in the infra-colic compartment of the abdominal cavity A series of interrupted sutures complete the fixation of the mesocolon to the anterior wall of the stomach well above the line of anastomosis.

A final inspection of the general position of the organs and of the vascular pedicles is made before closing the abdomen.

It is obvious that after either antecolic or retrocolic gastrectomy a space is left between the afferent jejunal loop in front and the mesocolon or colon behind, through which herniation of the efferent jejunum may and occasionally does occur It has been suggested that these spaces should be partially or completely closed by a few sutures between the afferent jejunum and mesocolon. This is a procedure which may well be added, and is particularly easy to carry out in the retrocolic operation

THE GASTRO-DUODENAL OR BILLROTH I (PEAN) ANASTOMOSIS

Mobilization of the stomach and duodenum proceeds as described in Illustrations 8–7 The duodenum is transected between a Payr's clamp proximally and a Lang Stevenson anastomosis clamp on the duodenal side after transection the clamped duodenum is covered by a small swab and returned to the abdomen to await anastomosis.

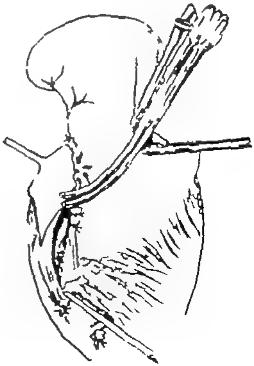
The stomach is further mobilized ready for transection as in Illustrations 12–14

Transection of the stomach

The formation of the gastric stoma

27 The stomach is lifted forward and a light Lang Stevenson clamp is placed from the greater curve side across at least half of the stomach diameter to form the stoma.

A Payr's clamp is placed just distal to this clamp and the stomach divided between the two.



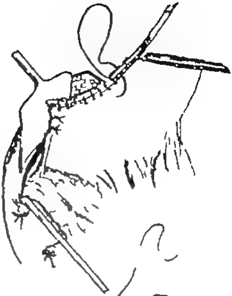
The lesser curve

28 A curved crushing Parker Kerr clamp is placed from the tip of the light clamp to skirt the ulcer margin on the lesser curve transection of the stomach is completed along this clamp and the specimen removed.

Formation of a new lesser curve

The all-coats layer

29 A continuous catgut suture over the Parker-Kerr clamp commences at the lesser curve. The clamp is removed and the suture drawn tight a loop at a time, with a final knot just beneath the tip of the light clamp



The sero-muscular layer

30 The previous suture line is buried by means of a continuous suture from the lesser curve to the tip of the light clamp

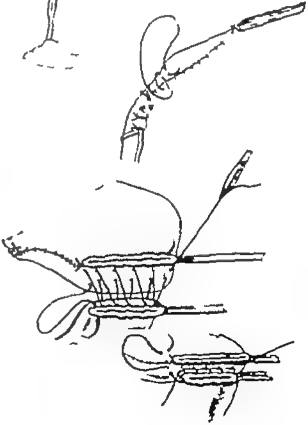
The anastomosis

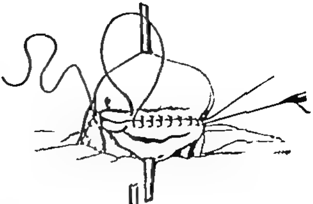
The posterior sero-muscular layer

31 The two light clamps are approximated and the posterior sero-muscular suture of catgut is commenced at the greater curve of the stomach without knotting

This stitch is inserted loosely and spirally (the "cork-screw stitch") and is not drawn tight until the posterior line has been completed thus the posterior walls of the stomach and duodenum are in full view throughout, so that the stitches may be placed exactly to allow for any disparity in size.

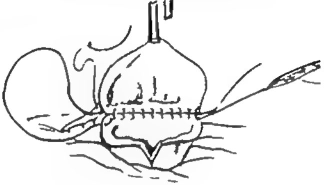
At the lesser curve end, the stitch passes through the superior duodenal wall and then through the posterior and anterior stomach walls just above the sero-muscular stitch of the lesser curve. The suture is then drawn tight, loop by loop





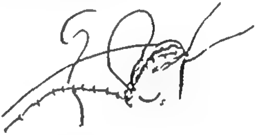
The posterior all-coats layer

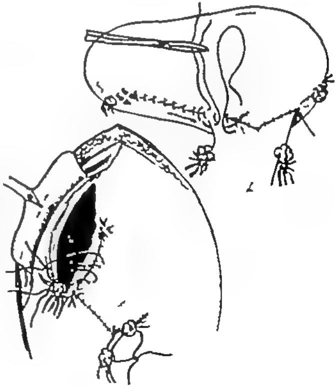
32 The clamps are removed and the posterior all-coats suture is inserted in the same manner as shown in Illustration 18. Small close stitches are employed to fasten down the thick gastric folds.



The anterior all-coats layer

33 The corner at the lesser curve is turned and the anterior suture inserted as described in Illustration 19. If any disparity exists between the size of the gastric stoma and the duodenum, a small longitudinal incision is made in the anterior wall of the latter.





The anterior sero-muscular layer

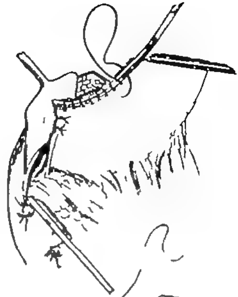
34 Before continuing the posterior Lembert suture along the anterior surface a single catgut stitch is inserted in the "critical angle" between the closed lesser curve and the superior border of the duodenum. This stitch is not tightened and tied until the anterior sero-muscular suture has been completed.

A further 2–3 interrupted stitches are inserted between the new lesser curve and the right gastric pedicle and remains of the hepato-gastric ligament, to draw the stomach over to the right. If the anastomosis is under the slightest tension the duodenum is freed by dividing the peritoneum along its lateral border and mobilizing it towards the left.

Formation of a new lesser curve

The all-coats layer

29 A continuous catgut suture over the Parker-Kerr clamp commences at the lesser curve. The clamp is removed and the suture drawn tight a loop at a time, with a final knot just beneath the tip of the light clamp



The sero-muscular layer

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The anastomosis

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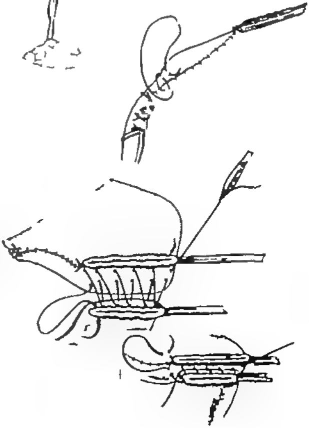
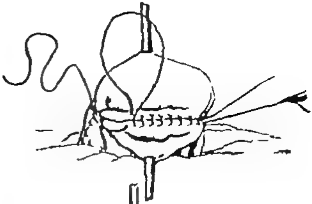
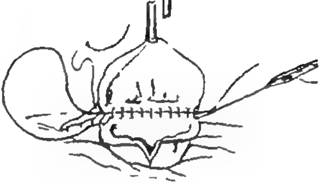




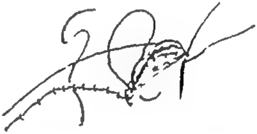
The posterior all-coats layer

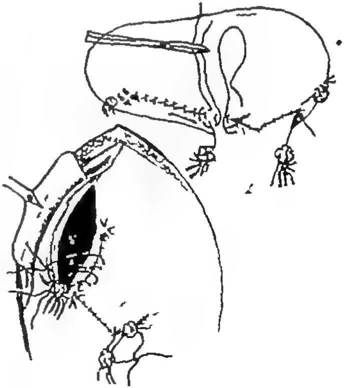
32 The clamps are removed and the posterior all-coats suture is inserted in the same manner as shown in Illustration 18. Small close stitches are employed to fasten down the thick gastric folds.



The anterior all-coats layer

33 The corner at the lesser curve is turned and the anterior suture inserted as described in Illustration 19. If any disparity exists between the size of the gastric stoma and the duodenum, a small longitudinal incision is made in the anterior wall of the latter.





The anterior sero-muscular layer

34 Before continuing the posterior Lembert suture along the anterior surface, a single catgut stitch is inserted in the "critical angle" between the closed lesser curve and the superior border of the duodenum. This stitch is not tightened and tied until the anterior sero-muscular suture has been completed.

A further 2–8 interrupted stitches are inserted between the new lesser curve and the right gastric pedicle and remains of the hepato-gastric ligament, to draw the stomach over to the right. If the anastomosis is under the slightest tension the duodenum is freed by dividing the peritoneum along its lateral border and mobilizing it towards the left.

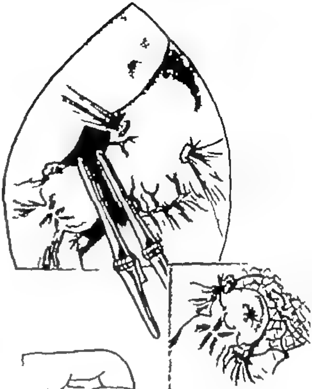
The Difficult Ulcer

THE POSTERIOR PENETRATING DUODENAL ULCER

Method 1 Pre-ulcer post-pyloric closure

For ulcer in the second part of the duodenum with a healthy bulb This method is possible in only a small percentage of these cases.

35 The first part of the duodenum is dissected clean in the usual manner but the ulcer is not touched. The transection is made as near to the pylorus as possible, and the duodenal stump closed by the method shown in Illustrations 9–11



Method 2 Open closure of the duodenum, distal to the ulcer

For a posterior penetrating ulcer in the first part of the duodenum.

Exposure and mobilization proceed in the usual manner until the right gastric pedicle has been divided and the superior border of the duodenum dissected (Illustration 7)

Further dissection of the duodenum

36 The duodenum is entered by blunt dissection at the upper edge of the ulcer crater where the duodenal wall is adherent to the scarred pancreas.

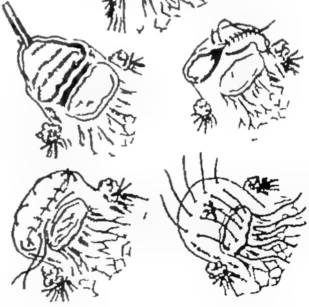
The index finger is inserted into the lumen of the duodenum, and by sharp scalpel dissection the posterior duodenal wall beyond the ulcer is freed from the scarred pancreatic tissue for a sufficient distance to make possible sound closure.

The duodenum is transected somewhat obliquely

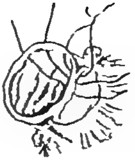
Duodenal closure

37 After insertion of a continuous over-and-over stitch commencing posteriorly to close the lumen, a purse-string suture is introduced, followed by a series of interrupted thread sutures to draw the anterior duodenal wall well over to the scarred pancreas.

Finally the pedicles are drawn over as in Illustration 11 and a valved Balfour gastrectomy performed as described.



Method 3 Alternative method of open closure of the duodenum



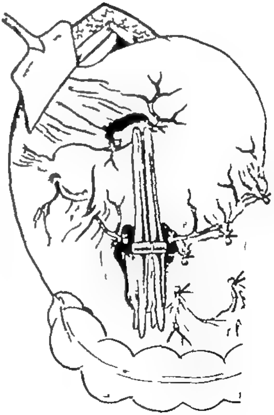
38 If the ulcer is too large or too distal to allow dissection of the duodenal wall beyond the ulcer without undue danger to the common bile duct, the duodenum is transected, after opening the ulcer as in Illustration 3C opposite the proximal edge of the ulcer

Continuous or interrupted sutures are placed between the cut edge of the duodenum and the distal ulcer edge to obtain sound closure

A further layer or two layers, of interrupted sutures are placed between the sero-muscular coat of the duodenum (anterior wall) and the proximal ulcer edge or adjacent fibrotic pancreas.

Note—If any doubt exists with regard to the safety of the duodenal closure a corrugated drain should be placed down to the stump at the end of the operation

Method 4 Pre-pyloric closure



For a very difficult ulcer extending into the second part of the duodenum but with a healthy pylorus.

Preliminary mobilization

39 The gastro-colic omentum is divided as shown in Illustration 8 to within 2·5 cm. of the pylorus. At this level the gastro-epiploic arch is divided between ligatures and a small area of greater curve cleaned.

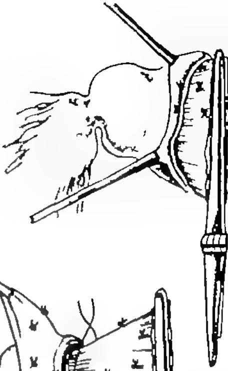
Opposite this cleaned area, the coronary arch is divided and an area of lesser curve also cleaned.

Two Payr's clamps are applied across the antrum at this level and the stomach divided between them either at this stage or when convenient.

Sero-muscular dissection

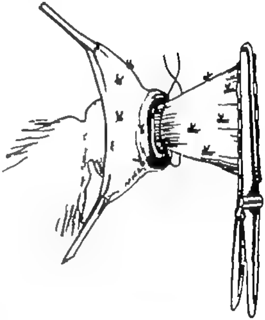
40 An incision is made immediately distal to the clamp round the circumference of the antrum, through the sero-muscular coats down to but not through the mucosa.

The sero-muscularis is dissected from the mucosa in this plane right down to the pyloric ring which is recognized as a circular band of muscle. Small perforating vessels are ligated as they are encountered.



Closure of the pyloric mucosa

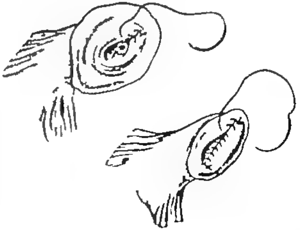
41 A simple ligature is tied round the pyloric mucosa at its narrow point, and the mucosa transected just proximal to the ligature.



Closure of the sero-muscular layer

42 The sero-muscular stump is closed from within by a series of stitches, commencing at the pyloric ring and approximating the opposing surfaces.

A final suture closes the cut end of the stump



Method 5 Antral transection

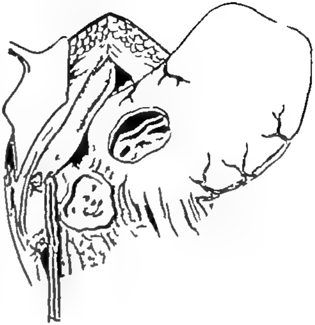
In a frail subject with a difficult duodenal ulcer simple transection and closure of the antrum may occasionally be justified as a first stage, if more extensive procedure carries undue risk to life. This method will necessitate a further operation for excision of the antrum, 6–8 weeks later

THE HIGH POSTERIOR PENETRATING GASTRIC ULCER

Separation of stomach from ulcer bed

43 After division of the duodenum the stomach is turned over to the left to expose the adherent area the posterior wall of the stomach is then freed by "pinching it off" from the penetrated structures between thumb and finger Occasionally there is so much fibrosis that sharp dissection is required but care must be taken not to cut into the pancreas.

The advantage of "pinching off" is that the stomach separates from the invaded organ at the exact junction of the two tissues, and as a result, no gastric mucosa is left on the invaded organ, and there is no danger of cutting into the invaded organ—which may be pancreas or even aorta.



Closure of gastric wound

44 After aspirating the stomach contents through the hole in the posterior wall of the stomach, this hole is temporarily roughly closed with a single strong continuous suture to prevent spillage.

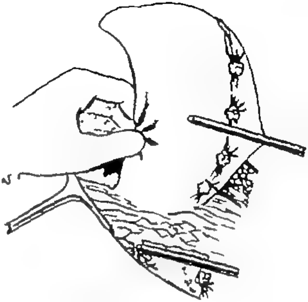
The stomach can now be drawn out of the wound, and the left gastric vessels and the vasa brevia are dissected and divided as described in Illustrations 12-14

It used to be the practice to cauterize or otherwise treat the ulcer base which remains over the organ penetrated by the ulcer Such procedures are unnecessary and may even be highly dangerous for they may lead to necrosis of part of the pancreas with subsequent pancreatic leakage The crater should, of course, be carefully inspected and any artery or duct seen should be under-run with a ligature. If very extensive pancreatic penetration has occurred, a drain may be put down to it.

The Pauchet procedure and the rotation manoeuvre

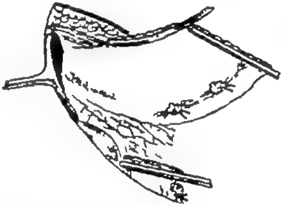
45 The Pauchet procedure taking a tongue of lesser curve containing the ulcer is used for any high lesser curve ulcer It may be combined with the "rotation" manoeuvre if the ulcer penetrating or otherwise, is situated on the posterior wall of the stomach.

The ulcer is grasped between thumb and finger and held as though it were situated on the lesser curve the true lesser curve will now be lying anteriorly and the greater curve posteriorly The Stevenson clamp is applied at the selected level across the anterior wall of the stomach, which now forms a new greater curve.



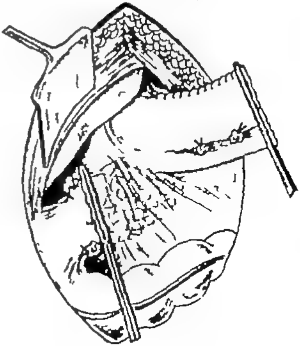
The gastric transection

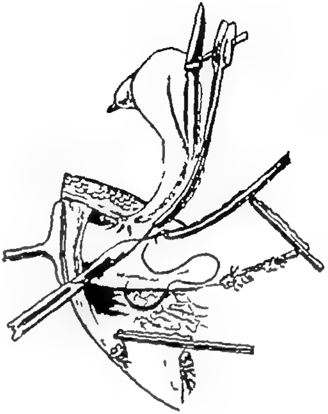
46 Transection is made distal to the Stevenson clamp, and a Parker-Kerr clamp is now placed on the posterior wall of the stomach to skirt the ulcer and form a new lesser curve. Transection distal to the Parker-Kerr clamp will allow the specimen to be removed with the tongue-shaped segment of posterior wall containing the ulcer Closure of the new lesser curve proceeds in the manner depicted in Illustrations 29 and 30



Duodenal-gastric approximation

47 The clamps on the duodenum and on the tube-shaped gastric remnant are approximated and a Billroth I anastomosis is carried out as described in Illustrations 31–34

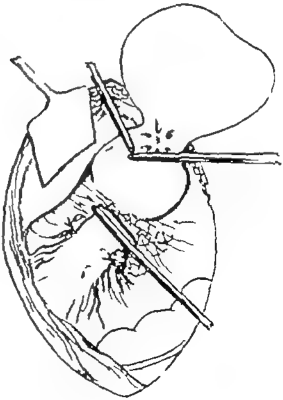




THE VERY HIGH SUB-CARDIAC ULCER

48 If the ulcer is too high for the Parker Kerr clamps to be placed above it, the tongue-shaped piece of lesser curve containing the ulcer is excised free-hand, segment by segment, the cut edges being closed with a continuous all-coats suture as the incision is carried further up towards the cardia.

This suture line is buried with a continuous sero-muscular suture as previously described care being taken to avoid undue narrowing of the oesophagus if the incision encroaches the cardia



THE HOUR-GLASS STOMACH

49 The presence of hour-glass contracture may make the Pauchet procedure and formation of a tube-like remnant for gastro-duodenal anastomosis difficult or impossible, and necessitate resection of the stomach above the hour-glass constriction. Though this is so a partial gastrectomy is still preferable to alternative procedures such as gastro-gastrostomy or gastro-jejunal anastomosis above the constriction but as much stomach should be conserved as possible.

If full mobilization of the duodenum by Kocher's method does not permit a gastro-duodenal anastomosis without tension, a gastro-jejunal anastomosis will be necessary

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

If a blood transfusion or intravenous saline has been used during the operation, this may be continued for 24 hours after operation, particularly in hot weather or if the patient perspires freely In other cases, a slow rectal drip will suffice until fluids can be taken by mouth, usually 18–24 hours after operation

The naso-gastric tube should be left in for 24 hours after operation, and passed every morning for 2 days thereafter to aspirate the stomach. After this, it will only be required if there is gastric distress, hiccough or vomiting, or if there is evidence of gastric retention Milk and egg can be given about the third day and a light diet by the fifth day An enema or suppository is usually needed on the third day

Post-operative haemorrhage

If concealed and intra-abdominal, splenic damage should be suspect—which may need reintervention. Very slight bleeding from the suture line with a coffee grounds aspirate is normal for a few hours. Severe and repeated vomiting of blood and clots should be treated like massive ulcer haemorrhage and if continued, re-operation and gastrotomy may very occasionally be required to find the bleeding point.

Duodenal stump or suture line leakage

If this is suspected, gastric aspiration, intravenous saline therapy and urgent operation to drain and, if possible, resuture the affected area will be required.

Post-gastrectomy diarrhoea

Mild diarrhoea may be treated by giving dilute hydrochloric acid 3 drachms in water 4-hourly or by intestinal antiseptics—for example Sulphathalidine. Severe cases, which may result from necrotizing enteritis, require the intravenous administrations of very large quantities of saline and plasma to prevent collapse from fluid and electrolyte depletion.

Pulmonary complications

Pulmonary complications, particularly minor degrees of pulmonary collapse, are common. They may be largely prevented by pre-operative and post-operative respiratory exercises. Antibiotics may be required in treatment, but *every effort should be made to enable the patient to expel his bronchial secretions.*

Vascular complications

Thrombotic and embolic complications may occur and the customary limb prophylaxis and careful observation for signs of posterior tibial or femoral thrombosis are desirable.

[The Illustrations for this Chapter on Partial Gastrectomy were drawn by Mrs. J Mare.]

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OPERATIONS FOR BLEEDING PEPTIC ULCER

NORMAN C TANNER, M D F R C S

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PRE-OPERATIVE

Indications

Surgical intervention for bleeding peptic ulcer is indicated in patients who give a history of chronic peptic ulceration, who are middle aged or elderly and who are either admitted with shock from a catastrophic haemorrhage or who have a repetition of haemorrhage after admission to hospital, or who continue to bleed after admission to hospital. While no hard and fast rules can be laid down, certain other features may influence the decision. Pain persisting after the ulcer has bled, arteriosclerosis, and evidence that the ulcer is gastric, are all further incentives to surgery A *second* repetition of bleeding in the hospital is an indication for surgery even if there is little or no ulcer history for a callous ulcer will be found in many such cases. Young patients, under 80 years of age can withstand the effects of haemorrhage better than the elderly and the indication for surgery is less acute in such patients, though it is to be borne in mind that young patients may die of ulcer bleeding

It is an advantage to come to a decision without too much prevarication, preferably within 48 hours of the onset.

Associated ulcer haemorrhage and perforation must always be treated surgically Associated stenosis of the ulcer is also an added indication for operation.

Special contra-indications

If there is any suspicion that the bleeding is due to oesophageal varices, balloon traction of the cardia must first be made and if this fails an emergency transthoracic porto-azygos disconnexion will cause cessation of the bleeding (Tanner 1954)

Evidence that the bleeding is due to or accelerated by systemic disease, for example uraemia, haemophilia, purpura or multiple telangiectasia, is a contra-indication to surgery

Special equipment

It is well to be prepared to proceed to thoracotomy in case a high gastric lesion is found which cannot be dealt with abdominally

Pre-operative preparation

Many cases will have been under a physician and treated by adequate feeding and restoration of the blood volume by transfusion. In urgent cases coming direct to the surgeon it is important to have a good blood transfusion in place prior to operation, in some severe cases two transfusions may be required.

It is helpful if a small tube can be passed through the nares into the stomach for the purpose of aspirating the stomach contents before and during the operation.

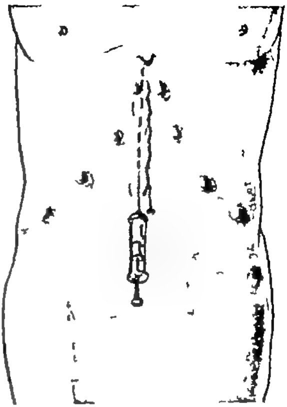
The patient is usually taken to the operation room in his bed or on a trolley which can be tilted into the Trendelenburg position.

THE OPERATION

The incision

1 A right upper paramedian incision from the xiphisternum to the level of the umbilicus is usually employed. A midline incision is quicker and less vascular and may be used if the patient is very ill.

It is found that patients stand the operation better if local anaesthesia is used, supplemented with morphine or Omnopon. An abdominal field block is introduced, using a solution of 1 : 2 000 Amethocaine with 1 : 400 000 adrenaline; the line of incision is also infiltrated. Immediately the peritoneum is opened an anterior splanchnic block is produced with 60 ml. of the same solution. If splanchnic anaesthesia is incomplete the mesenteries can be injected with local anaesthetic, the bulk of the anaesthetic fluid being placed round the right and left gastric and right gastro-epiploic arteries.



Examination for the bleeding point

2 A general examination of the abdominal contents is usually omitted when general anaesthesia is not used, but undue bleeding from the wound, or the presence of enlarged veins in the ligamentum teres are noted as indicating the possibility of portal hypertension. The appearance of the liver and palpation of the spleen may give an indication as to the cause of the hypertension. Failure of the blood to clot may occur in certain blood diseases. The presence of blood in the jejunum confirms the gastro-duodenal bleeding.

The stomach and duodenum are examined visually and by palpation for the source of haemorrhage.

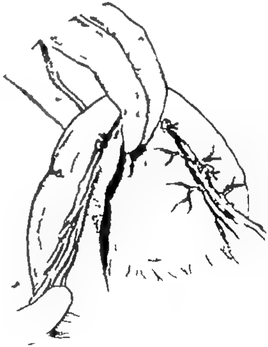
If no obvious cause of haemorrhage is located, and further examination of the whole small intestine, gall bladder and pancreas is also negative, the whole of the lesser curve region of the stomach is very carefully palpated between finger and thumb. The tiny bristle-like projection of a vessel into the base of a sub-acute ulcer may thus be felt.

Inspection of posterior wall

3 If this examination proves negative the posterior wall of the stomach is palpated and then *visualised* by turning it forward through a hole made in the gastro-hepatic omentum
An acute erosion which is sometimes the source of the haemorrhage may be impossible to detect by palpation but on careful inspection its presence may be detected by a slight stippling of the serosa overlying the area of superficial ulceration Other indications of a possible underlying ulcer are the presence of enlarged lymph nodes, or an adhesion or thickening of the adjacent omentum.
The discovery of a gastric lesion does not remove the need for very careful palpation of the stomach right up to the cardia or a second higher ulcer which may be the real source of the bleeding may be missed.

Examination of lower portion of duodenum

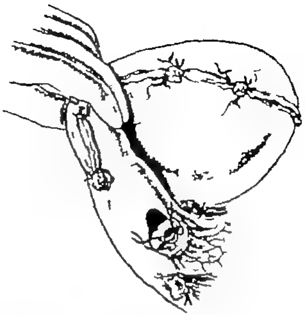
4 If no gastric ulcer is detected the posterior wall of the duodenum is inspected via the gastro-hepatic or the gastro-colic omentum. If no ulcer can be seen or felt in the first part of the duodenum the junction of the first and second parts and the second part of the duodenum are carefully mobilised, palpated and inspected for any evidence of stippling adhesion, ulceration or scarring If no ulcer or other cause of the bleeding can be detected and bleeding is severe, it is our practice to carry out a "blind" partial gastrectomy Not infrequently in such cases, examination of the excised stomach reveals the cause of the bleeding.



The bleeding duodenal ulcer

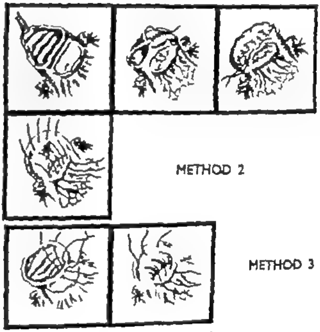
If a duodenal ulcer is discovered to be the source of bleeding the treatment of choice is partial gastrectomy

For a non-penetrating ulcer a valved Balfour gastrectomy is carried out as described in Partial Gastrectomy (page 75)



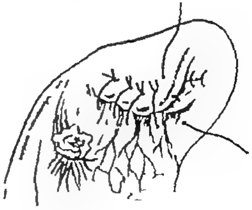
The posterior penetrating duodenal ulcer

5 The duodenum is opened as previously shown, page 88 Illustration 86 A bleeding vessel may be seen in the ulcer base in the pancreas. This is under-run with a strong suture.



Transection and closure of duodenum

6 The duodenum is transected and closed by Method 2 or Method 3 as described on pages 88 and 89



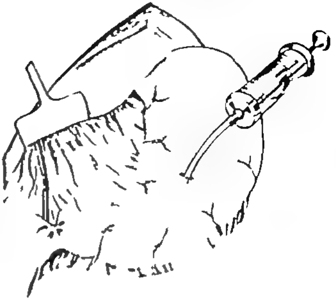
Filling in the ulcer crater

7 In closing the duodenum by either of these methods, the series of interrupted sutures between the anterior duodenal wall and the fibrotic pancreas are placed so as to produce maximum rolling of the duodenum into the ulcer crater to occlude any possible bleeding points by pressure.

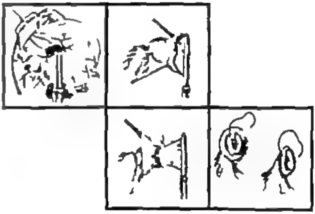
8 *The bleeding ulcer in the vicinity of the bile duct*

"*Irremovable ulcer: palliative procedures*.—If removal of the ulcer would entail grave risk to the common bile duct the ulcer may in some cases be left *in situ*.

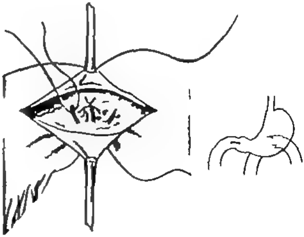
A small opening is made in the antrum and a fine catheter introduced into the duodenum. If aspiration of clear bile shows that bleeding is temporarily arrested a pre-pyloric closure is carried out.



9 *Pre-pyloric closure*.—The stomach is divided between Payr clamps. After dissecting back the sero-muscularis the underlying mucosa is excised and the stump closed (*see also* pages 89 and 90 Illustrations 39–42)



10 *Exposure of crater by duodenotomy*.—If aspiration shows the ulcer to be still bleeding the crater is exposed by duodenotomy and the bleeding vessel under-run (a very strong needle is necessary to pierce the fibrotic tissues). The lips of the crater are drawn together if possible. The duodenum is closed and a gastro-enterostomy performed.



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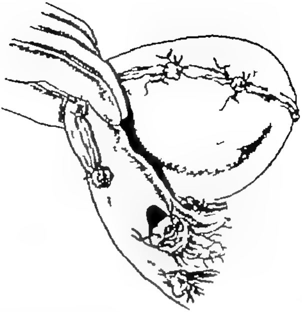

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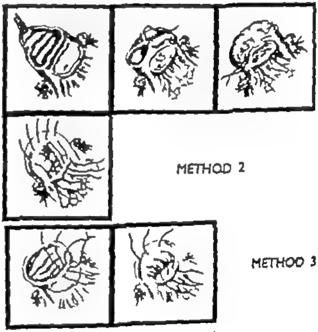
5 The duodenum is opened as previously shown, page 88 Illustration 88 A bleeding vessel may be seen in the ulcer base in the pancreas. This is under-run with a strong suture.



Transection and closure of duodenum

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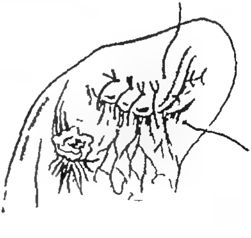

Filling in the ulcer crater

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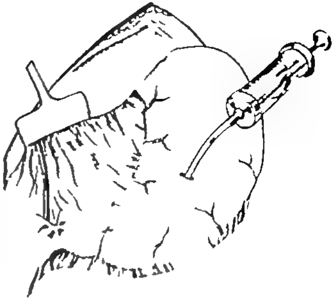
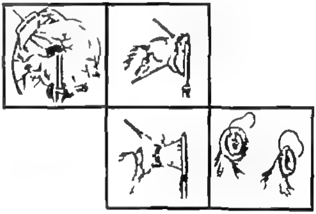
"*Irremovable ulcer palliative procedures.*—If removal of the ulcer would entail grave risk to the common bile duct, the ulcer may in some cases be left *in situ*

A small opening is made in the antrum and a fine catheter introduced into the duodenum. If aspiration of clear bile shows that bleeding is temporarily arrested a pre pyloric closure is carried out.



9 *Pre-pyloric closure*—The stomach is divided between Payr clamps. After dissecting back the sero-muscularis the underlying mucosa is excised and the *stump closed* (*see also* pages 89 and 90 Illustrations 39–43)



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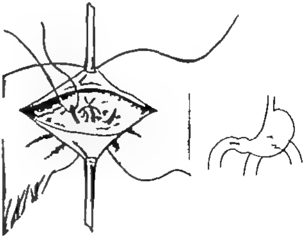
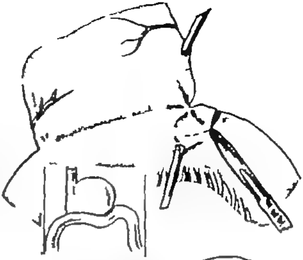


The bleeding stomal ulcer

11 The ulcer is excised locally and the defect repaired transversely

If this is not practicable, as for example in cases of stomal ulcer after gastro-jejunostomy the ulcer crater is exposed through an incision made in the anterior stomach wall and the bleeding vessel is under-run with fine non-absorbable sutures or the ulcer edges may be sutured together



The bleeding gastric ulcer

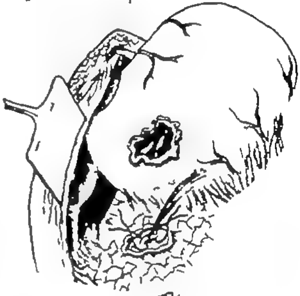
If a gastric ulcer is discovered to be the source of bleeding the treatment of choice is a partial gastrectomy

For a non-penetrating ulcer a Billroth I gastrectomy is carried out, as described on page 85

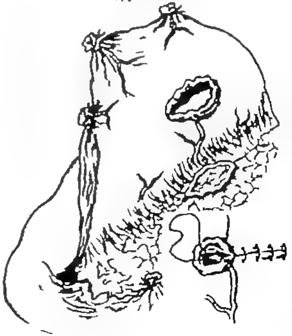
The posterior penetrating gastric ulcer

12 The ulcer is "pinched off" the pancreas (page 91 Illustration 48) A bleeding vessel may be seen in the ulcer base in the pancreas, and should be under-run with a non-absorbable deep suture. If this fails to control it, ligation in continuity of the splenic artery *on both sides* of the bleeding point will be necessary

Usually the bleeding is from the ulcer edge in the stomach wall and partial gastrectomy (by the rotation technique shown on page 92) will of course arrest it.

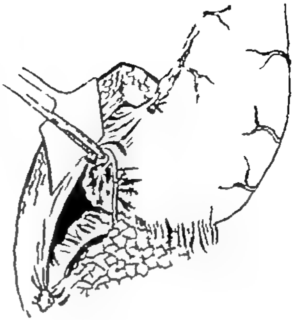


13 *Procedure in bad-risk cases*—If the patient is too ill or frail to withstand gastrectomy the edges of the ulcer are trimmed away until mucosa is seen all round, and the defect sewn up with two layers of continuous chromic catgut suture.



14 *The penetrating high lesser curve ulcer*

Bleeding is from the ascending branch of the left gastric artery. The left gastric pedicle is ligated near its base to control the haemorrhage. The mass of indurated tissue forming the ulcer base in the upper part of the gastrohepatic omentum is dissected from the lesser curve to just above the level of the ulcer and the stomach resected by the Pauchet technique (page 9?) that is, the level of greater curve gastric transection is low but a tongue shaped piece of lesser curve containing the ulcer is removed with the resected portion of the stomach.



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

The patient must remain in or adjacent to the operating room until his condition is satisfactory the blood drip being continued until the blood deficiency is reasonably corrected.

As the resistance of the anaemic patient to infection is lowered, prophylactic antibiotic therapy is of value.

Post-operative feeding and the management of the stomach tube is exactly the same as after elective gastrectomy for ulcer

Chronic ulcer patients sometimes have sub-clinical avitaminosis and so an injection of vitamins B and C should be given immediately before or after operation and adequate oral vitamin given thereafter Ferrous gluconate 5 gr three times daily will help to correct the anaemia.

Post-operative complications are the same and require the same prophylaxis and treatment as after elective gastrectomy

If a palliative procedure has been used, for example under-running of the bleeding point, consideration must be given to the necessity of later elective surgical intervention, either partial gastrectomy or vagotomy

[*The illustrations for this Chapter on Operations for Bleeding Peptic Ulcer were drawn by Mrs J Mace*]

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GASTRO-JEJUNAL ULCER AND GASTRO-JEJUNO-COLIC FISTULA

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PRE-OPERATIVE

Indications

Gastro-jejunal ulceration, with or without involvement of the colon, may follow after gastro-jejunostomy or partial gastrectomy. It may be possible to demonstrate the ulcer by means of a barium meal or by gastroscopy but it is not uncommon for these two investigations to provide inconclusive evidence and exploration to be undertaken mainly on clinical grounds, perhaps on account of pain, tenderness and repeated haemorrhage. A fistula into the colon can usually be shown radiologically and may provide unmistakable clinical evidence if gross faecal contamination of the stomach and upper small intestine has occurred. In a case of this kind diarrhoea is often severe and intractable, being due not to the mere fact of a short-circuiting stoma being present between stomach and colon but to the severe jejunitis caused by contamination with organisms from the large bowel. Dehydration and disturbance of plasma electrolytes may be marked. In such a case, before the final definitive operation is undertaken, a defunctioning colostomy may be performed as a first stage.

Pre-operative preparation

Anaemia must be corrected, electrolyte deficiencies made good by transfusion, and the patient put on a high protein, low residue diet. Where the colon is involved, phthalylsulphathiazole should be given for 8 days prior to operation. Gastric lavage is of value if there is any gross delay in the stomach or contamination by faeces.

A Ryle's tube should be in the stomach before the patient is anaesthetized.

Anaesthesia

General anaesthesia is used, with an endotracheal tube and cuff to prevent any regurgitation of material into the trachea and bronchi.

Selection of technique

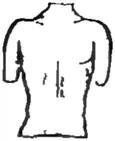
If a jejunal ulcer without involvement of the colon follows an adequate partial gastrectomy trans-thoracic vagotomy is probably the procedure of choice. If the ulcer follows gastro-jejunostomy the anastomosis must be undone the involved jejunum repaired or resected, and partial gastrectomy performed.

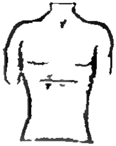
If the colon is involved, repair is carried out or much less frequently resection of a short length of bowel.

THE OPERATION

The incision

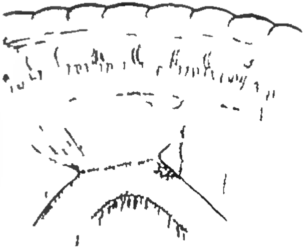
1 Most surgeons prefer to excise the original scar but there is much to be said for making a transverse incision dividing the recti from the tip of the right to the tip of the left ninth costal cartilage if the previous incision has been a vertical one and vice versa a midline approach being used if the previous incision was transverse Whichever approach is used a satisfactory exposure cannot be obtained without detaching adherent viscera from the back of the old scar





Method of exposure

2 Having entered the peritoneal cavity divide all adhesions which interfere with an adequate view of the stomach gastro-colic omentum and transverse colon.



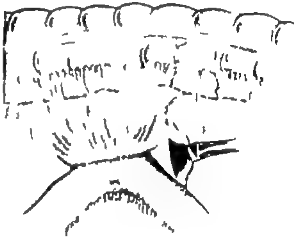
Additional exposure and identification of the middle colic artery

3 Bring the transverse colon and great omentum out of the wound, thus exposing the transverse meso-colon. Find the opening through which the jejunum passes, and identify the middle colic artery usually lying to the left of this. At this point the ulcer may be seen

4

Additional exposure when the colon is involved and a gastro colic fistula is present

In these cases it is often easier to expose the anastomosis and fistula by opening the lesser sac in the manner shown. This may apply to simple anastomotic ulcers when the transverse colon is firmly fixed posteriorly by adhesions or a shortened meso-colon.



5

Separating the middle colic artery from the anastomosis and ulcer or fistula, below the transverse colon

The transverse colon is gently lifted upwards, while the jejunum is displaced downwards. The opening in the transverse meso-colon is enlarged with scissors, and the middle colic artery retracted.

6

Separating the middle colic artery from the anastomosis and ulcer or fistula in the lesser sac

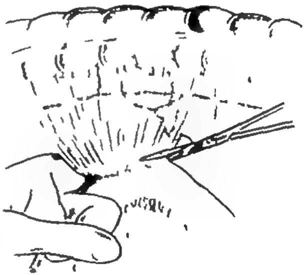
In these cases the transverse meso-colon has been thickened and shortened. Identification of the artery will usually depend on palpation and a very careful dissection is necessary

Freeing the anastomosis

7 When the anastomosis has been exposed and freed from adhesions the index finger of the left hand is passed posteriorly and hooked around it the tip passing between the bowel and the *middle colic artery*. The stomach and the jejunum, on each side of the anastomosis, are carefully freed from adhesion to the mesocolon before the two viscera can be separated.

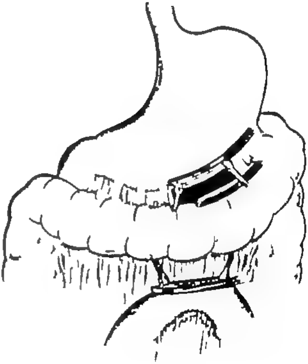
Dividing the anastomosis

8 The bowel is then brought nearer the surface and the anastomosis divided with scissors. The procedure is the same whether the division takes place below the transverse colon or in the lesser sac. If the ulcer follows gastro-jejunostomy and partial gastrectomy is to be performed and if the jejunum is grossly distorted at the anastomosis, division of the jejunum on each side of the anastomosis may be preferred.



Position of organs after separation and mobilization

9 If it has not been done previously the lesser sac is now opened. The openings in the various organs are clamped, and retraction of the cut edges prevented by approximating these with Allis forceps. The ulcer which is most commonly in the efferent loop is excised at this stage.



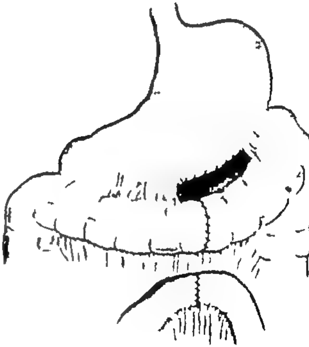
Position of organs after separation and mobilization with the colon involved

10 If, in spite of every precaution, the blood supply to the colon has been damaged, the devascularized portion must be excised. Before anastomosing the cut ends it is advisable to remove the clamps to make certain that there is an adequate blood supply as if not a further piece of colon must be removed. In practice, the transverse colon is not easily devascularized. If there is doubt, the colon is covered with a hot moist pack while the gastric resection is carried out. Re-assessment of the viability of the colon then allows a decision to be made about the advisability of resection of part of the colon.

11

Restoration of openings in stomach jejunum and colon by suture

The stomach can only be dealt with in this way if no ulceration is present there or in the duodenum and the pylorus is not stenosed. The jejunum should only be sutured if as a result the lumen is not unduly narrowed and the colon if there is no gross distortion and that portion of the bowel is viable. The cut ends should be excised to ensure suturing healthy tissue and approximated longitudinally in the stomach, and transversely in the jejunum and colon



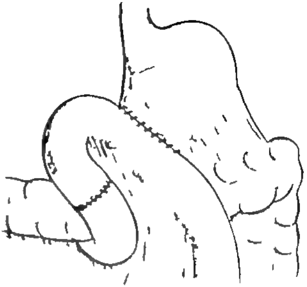
12

Restoration of the jejunum and colon by resection and anastomosis

This is the more common procedure, particularly in the jejunum. Where dismantling is sufficient (10 *per cent of cases*) this terminates the operation. If the jejunal segment is not resected, the longitudinal opening into it is closed transversely to avoid later stenosis. This often gives the *jejunum* a rather untidy "dog-eared" appearance, but the functional result is excellent.

The completed partial gastrectomy

13 In 90 per cent of cases it is usual to proceed to an ante-colic (Polya) partial gastrectomy The opening in the transverse meso-colon must be repaired.



Closure

The wound is then closed in layers. It is a wise precaution to insert a soft rubber drain down to the duodenal stump for a little oedema and temporary obstruction at the site of jejunal repair can produce a "closed loop" of the duodenum and first 1–2 inches of jejunum. The pressure in this will rise and leakage becomes a distinct risk

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

The Ryle's tube should be left in until bowel sounds return, usually on the second or third day Stomach contents should be aspirated 4-hourly unless the patient complains of nausea when aspiration should be more frequent.

Intravenous fluids

Blood transfusion is usually necessary and in addition fluids in the form of 4 3 per cent glucose and 0 18 per cent normal saline solution should be given during and immediately after the operation. This should be continued if the aspirations exceed the oral intake or if there are any signs of dehydration.

Fluids by mouth

One pint of fluid may be given in the first 24 hours 2 pints in the second. Solids may be given on the fourth day and a normal diet on the seventh.

Post-operative ileus

If this is prolonged, feeding by mouth must be reduced or abandoned and the patient's condition maintained by intravenous fluids.

Fistula

The drainage tube is removed on the fourth day If a fistula develops it should be treated by suction and the skin protected with aluminium paste or a barrier cream. Most close spontaneously and, unless the patient's condition is deteriorating and the loss of fluids and secretion increasing are best treated conservatively

[The illustrations for this Chapter on Gastro-jejunal Ulcer and Gastro-jejuno-colic Fistula were drawn by Mr F Price]

GASTRECTOMY FOR CANCER

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Surgeon Charing Cross Hospital Senior Surgeon St James Hospital London

PRE-OPERATIVE

Indications

Exploration with a view to radical gastric resection is justifiable in all cases of diagnosed gastric malignancy unless there is evidence of distant metastases. Even strong suspicion of cancer is enough to justify laparotomy unless the diagnosis can be disproved. In the presence of distant metastases, palliative non-radical resection or short-circuit is justifiable if the primary tumour gives rise to distressing symptoms—for example vomiting dysphagia or persistent bleeding

Special contra-indications

Penetration of the growth into a neighbouring organ or into the parietes is not a contra-indication to resection unless an irremovable organ, for example the aorta is invaded.

Special equipment or apparatus

One should not embark on operation for gastric malignancy unless one has the instruments and facilities for thoracotomy as well as for laparotomy

Pre operative preparation

The patient should be in hospital for a few days rest and preparation prior to operation.

If there is oesophageal obstruction intravenous and rectal infusions should be given. Sometimes, a fine catheter can be passed through the obstruction and a nutrient fluid drip given by this route. If there is pyloric obstruction, a course of gastric lavage with saline solution will help and parenteral fluid and electrolytes can be given.

Whenever possible a high protein diet must be given. Sub-clinical vitamin deficiencies may be present and so vitamins B and C should be given as a routine. If there is any anaemia, iron may be given by mouth, and blood transfusions if necessary

Pre-operative physiotherapy mainly directed to limb and breathing exercises, is helpful.

Anaesthesia

General anaesthesia is desirable in most cases. Local infiltration of the abdominal or thoracic incision with local anaesthetic combined with adrenaline 1 400 000 will diminish blood loss from the incision.

Position of patient

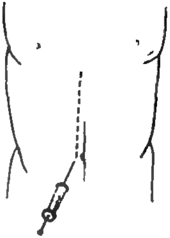
The dorsal position will be required for abdominal operations for cancer of the lower stomach. For cancer of the upper stomach, an abdomino-thoracic incision will be used. For this the patient must be firmly fixed on his right side, with the left arm pulled forwards and upwards to draw the scapula high up on the chest wall. It is an advantage to use an operation table capable of being tilted, a slight dorsal tilt being used while the abdominal part of the operation is in progress, and a slight ventral tilt for the higher work on the oesophageal anastomosis.

THE OPERATION

OPERABLE GROWTH OF THE PYLORUS OR ANTRUM

Radical Subtotal ("Lower Partial") Gastrectomy

The word "radical" infers that adjacent glands and omenta are also removed. "Lower partial" means a segment of duodenum and stomach.



The incision

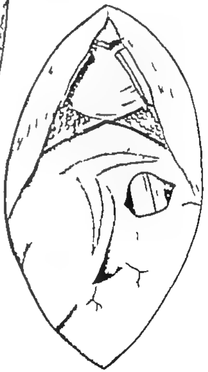
A right upper paramedian incision is used, after infiltration with adrenaline and amethocaine solution, as for a simple partial gastrectomy for ulcer.

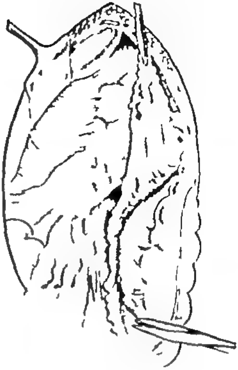
Removal of xiphoid process

1 The incision may be extended upwards by removal of the xiphisternum to allow better access to the region of the cardia. The xiphoid process varies greatly in size in different individuals. It is freed by first of all dividing the costo-xiphoid ligaments which run to its lateral surface. The slips from the diaphragm must be separated from its posterior aspect. Finally its base is divided with a bone forceps. Having removed the xiphoid process, the anterior peritoneal incision is continued up the anterior aspect of the diaphragm taking care not to open the pericardium.

Splitting of sternum

2 If exposure is still found inadequate the mediastinal contents may be separated by blunt dissection from the back of the lower sternum and the sternum split in the midline as high as the fourth interspace using a hammer and Loebsche's sternotome. The split should be carried into this interspace on each side allowing outward retraction of the lower chest wall by means of manual retractors.





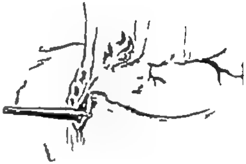
General examination of the extent of the growth

The resectibility of the growth is assessed and involvement of lymph nodes and invasion of other organs is looked for The whole abdomen is explored for distant metastases, for example in pelvis, ovaries or liver

Mobilization of the stomach

Separation of greater omentum from colon

3 The great omentum is separated by blunt and occasional sharp dissection from the colon and mesocolon and turned upwards, so that the greater curve is mobilized from the gastro-splenic ligament down to the pylorus. The colon and great omentum being attached only by embryonic adhesions, theoretically no vessels should be divided. In practice a few fine vessels will need ligature but a warm swab will arrest most of the bleeding



Sub-pyloric dissection

4 Any glands round the gastro-duodenal and right gastro-epiploic arteries and vein are stripped up towards the stomach and the gastro-epiploic vein and gastro-duodenal artery ligated and divided behind the duodenum

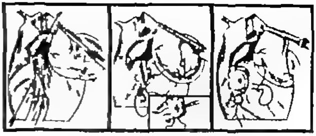
Dissection of the lesser curve

5 The lesser omentum is divided close to the liver The right gastric artery is dissected and any glands in this region are stripped towards the stomach. The right gastric artery is divided near its origin.

6

Division and closure of the duodenum

The duodenum is divided between crushing (Payr) clamps well distal to the pylorus, and is closed by the method shown on pages 78 and 79 Illustrations 9–11

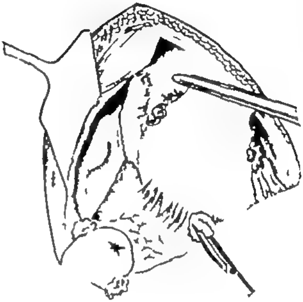


7

Further mobilization of the stomach

Stripping of the peritoneum in relation to the growth

The peritoneum over the front of the body of the pancreas, which may have been lying in contact with the growth, is stripped to the left with the specimen until the left gastric pedicle is reached, leaving bare the body of the pancreas and hepatic artery Any enlarged lymph nodes in contact with the hepatic artery should be stripped away as well.



8

Dissection of the left gastric vessels

After dividing the peritoneum over the pancreas, anterior to the left gastric vein, all glands and loose tissue round the coeliac axis, hepatic and splenic arteries are stripped up towards the stomach, leaving bare the origin of the left gastric artery and vein. These vessels are ligated and divided separately

Exposure of the cardia

9 The stomach is drawn down and to the left, the division of the lesser omentum is continued as far as the cardia, and the peritoneum divided across the lower oesophagus. Division of the left triangular ligament and reflection of the left lobe of the liver to the right may be necessary to obtain good exposure

Dissection near the cardia

10 The glands and tissues round the oesophagus are divided and stripped downwards, and the lesser curve is cleaned by division of the small vessels entering the upper $1\frac{1}{2}$–2 inches.
This involves division of many of the branches of the vagus nerves, and the branch of the anterior gastric nerve running to the liver will also be sacrificed. The vessels running to the lesser curve of the stomach are usually in pairs, anterior and posterior with occasional extra vessels running into the middle of the denuded area.

Division of the short gastric vessels

11 Mobilization is completed by ligation and division of the vasa brevia close to the splenic hilum. Care must be taken not to tear any fine splenic adhesions, or to take the vessels too near the splenic hilum or the splenic capsule may be torn and bleed persistently If such should occur a piece of crushed muscle or oxycel gauze may be placed on the damaged part of the spleen, but if bleeding persists the spleen should be removed (taking also the lymph glands in the splenic hilum)

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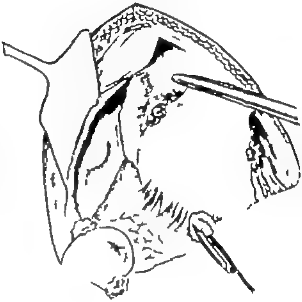

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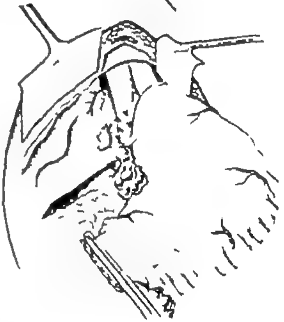

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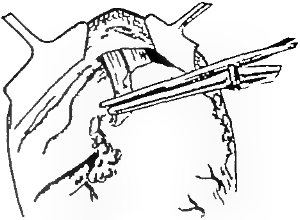
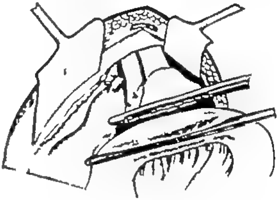
Transection of the stomach and anastomosis

Application of the stomach clamp

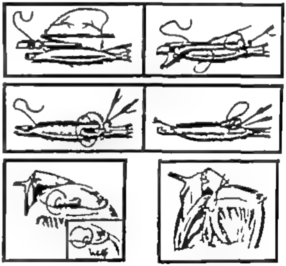
12 The stomach is clamped a little below the cardia, after freeing a selected part of the greater curvature of fatty and vascular tissue.





Preparation for anastomosis

13-14 The proximal jejunal loop is brought up in front of the colon, and anastomosis performed as described on pages 80–82 Illustrations 16–21 The loop should have only a short length (3–5 inches) of jejunum between it and the duodeno-jejunal junction.

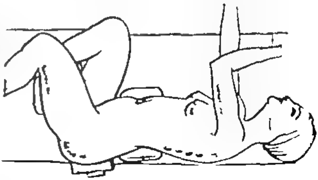


OPERABLE GROWTH OF THE MIDDLE OR UPPER HALF OF THE STOMACH

RADICAL TOTAL GASTRECTOMY

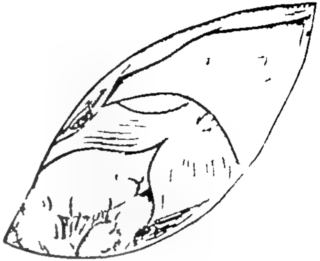
The incision

15 The patient is placed in the right lateral position. In addition to general anaesthesia, a local anaesthetic may be injected into the posterior parts of the lower six subcostal grooves to block these intercostal nerves.
The line of incision lies over the eighth rib from just behind the angle and extends across the costal margin and upper abdomen to a point approximately midway between the xiphisternum and the umbilicus. Wound bleeding is diminished if this line is infiltrated with local anaesthetic and adrenaline solution.
The anterior (abdominal) end of the incision is made first, and a hand is introduced into the abdominal cavity to assess the resectibility of the growth.
If the growth is considered removable, the incision is carried along the eighth rib, the rib excised and the costal margin divided. The pleural cavity is opened.



Exposure of the upper stomach

16 Further exposure is obtained by division of the diaphragm into the oesophageal hiatus. In cases where the diaphragm is invaded by tumour the hiatus margins may be excised with the stomach, and so the incision goes around the hiatus. Many bleeding points will require ligation in the diaphragm

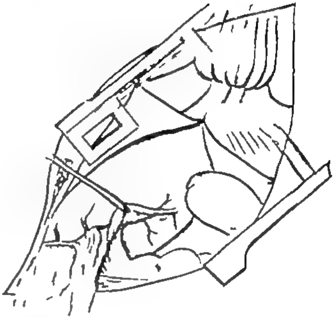


Mobilization of the stomach

Mobilization of the greater curve

17 It is helpful to fix the cut surfaces of the diaphragm to the intercostal muscles, thus avoiding the need for its separate retraction A large (Finochietto) rib retractor is inserted and opened widely

The great omentum is then stripped off the colon throughout its length and reflected upwards, as in the lower stomach resection (page 111 Illustration 9)

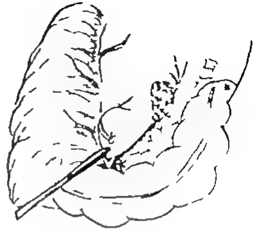


Dissection of the pancreatico-lienal glands and division of the splenic vessels

18 The spleen is turned forward and the lieno-renal ligament divided. If the posterior wall of the lesser sac and pancreas are not involved or in contact with growth, the splenic artery and vein are divided after ligation, close to the tail of the pancreas, thus taking the pancreatico-lienal glands with the spleen.

Sub-pyloric dissection

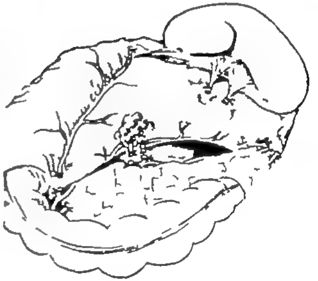
19 The sub-pyloric glands are dissected and stripped up towards the pylorus, after cleaning the right gastro-epiploic vein and artery which are ligated and divided separately near their origin.



Left gastric pedicle dissection

20 The stomach and spleen are turned upwards and the left gastric pedicle approached from the lesser sac aspect. All glands in this region (middle supra-pancreatic group) are stripped up towards the stomach, and the cleaned left gastric vessels are ligated and divided separately near their origin.

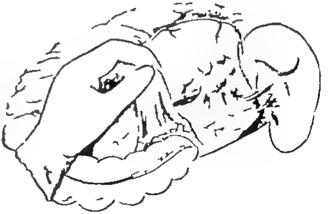
The coeliac branch of the posterior vagus is identified and divided as a separate structure, lying just cephalad of the left gastric artery



Dissection of posterior wall of lesser sac and pancreas

Invasion of the lesser sac by growth

21 If the growth is in contact with or involving the posterior wall of the lesser sac and the pancreas, the splenic vessels are not divided near the hilum of the spleen instead, preparation is made also to resect the body and tail of the pancreas and the peritoneum of the posterior wall of the lesser sac.

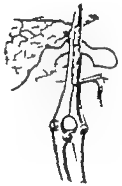


Mobilization of the pancreas

22 The whole of the peritoneum of the posterior wall of the lesser sac and over the front of the portion of the pancreas to be retained is stripped upwards.
The tail of the pancreas is turned forwards and the splenic vein is ligated just distal to the point of entry of the inferior mesenteric vein in order to retain a blood flow through the portal vein and so diminish its chance of becoming thrombosed.

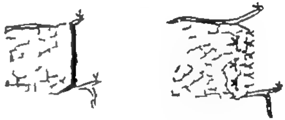
Transection of the pancreas

23 Further mobilization of the pancreas is carried out as far as necessary and the splenic artery is isolated, ligated and divided near its origin. A Payr's clamp is placed across the body of the pancreas at the point decided for transection, and the organ is cut across distal to the clamp. The stump is closed by a series of overlapping interrupted mattress sutures followed by a continuous over-and-over suture after removal of the Payr's clamp.



Author's method of closure of the pancreatic stump

24 An alternative method which may be used for closure of the pancreatic stump is to make a fish-tail shaped transection of the pancreas. The resulting V-shaped defect in the end of the pancreas is easily closed by suturing the raw surfaces together.

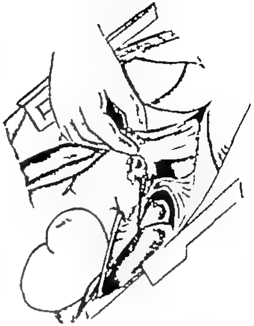


Dissection of the coeliac axis

25 Any glands round the coeliac axis and the hepatic and splenic arteries are dissected upwards towards the stomach, and the left gastric artery is ligated and divided at its origin, the left gastric vein being cleaned and ligated separately. (Considerably more pancreas is usually removed than is here illustrated, the usual site of transection being opposite the coeliac axis.)

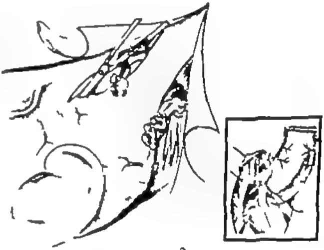
Mobilization of the cardia

26 The stomach is turned down and the upper part of the lesser sac is dissected from the perinephric tissue and left supra-renal gland.
The lower oesophagus is mobilized after all the lymph nodes and fatty tissue in the inferior mediastinum above the cardia have been stripped downwards towards the stomach.



Mobilization of lesser curve and removal of stomach

27 The highest part of the gastro-hepatic omentum is divided close to the liver taking care to divide any vessels in its uppermost part between ligatures. It must be remembered that at times the liver gets its blood supply from the left gastric artery and this anomalous vessel will run in the hepato-gastric ligament. If this vessel is found and it is as large as, or larger than the main hepatic artery it must be preserved and the left gastric artery must be divided only after this branch has been given off. A search for such a vessel should be part of the preliminary examination of the stomach. (The position of this vessel is depicted.) Any glands around the right gastric pedicle are stripped towards the stomach, and the right gastric vessels are ligated and divided at their origin.

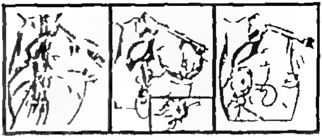


Duodenal mobilization

28 The duodenum is mobilized for a short distance beyond the pylorus, and peri-duodenal tissue stripped towards the stomach.

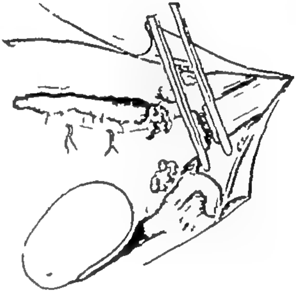
Transection of the duodenum

29 The duodenum is transected between Payr's clamps, and the stump closed as shown on pages 77 and 78 Illustrations 9–11 The stump of duodenum will be very short and one will often have to be content with one all-coats suture and one purse string invagination As the adjacent vascular pedicles will be short it will be impossible to reinforce the closed duodenum by suturing the pedicles over its closed end. Reinforcement if required may be obtained by placing sutures between the lateral wall of the duodenum and the adjacent pancreas.



Transection of oesophagus

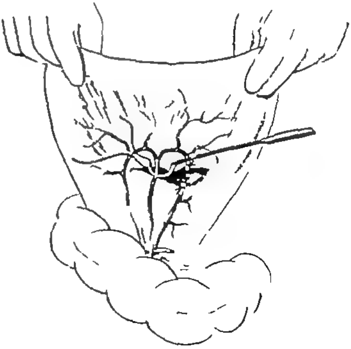
30 The oesophagus is transected well above the upper limit of the growth between a Payr's and a Stevenson's clamp and the stomach is removed. As the Stevenson clamp is a light crushing clamp a short segment of tissue must be left projecting from it, or the clamp may slip off While awaiting preparation of the jejunal loop the clamp and projecting piece of oesophagus should be surrounded by a gauze swab to prevent soiling of the mediastinum.



Preparation of the jejunum for a Roux-en-y form of anastomosis

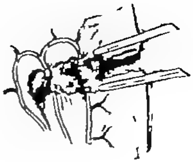
Selection of the jejunal loop

31 The mesentery of the jejunum adjacent to the duodeno-jejunal flexure is inspected till a loop with a satisfactory vascular anatomy is found. One or two of the feeding vessels (vasa intestinae tenuis) to the arcades are carefully dissected the artery and vein being ligated and divided separately and care being taken to preserve a good vascular flow through the arcades.



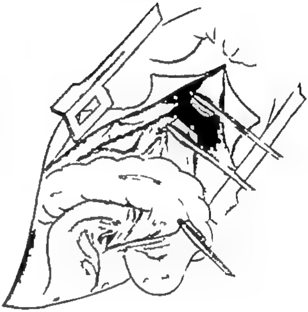
Transection of Jejunum

32 The jejunum is transected at the appropriate site between Stevenson's clamps. The proximal end is covered with a small swab and returned to the abdomen to await later anastomosis.



Positioning of the jejunal loop

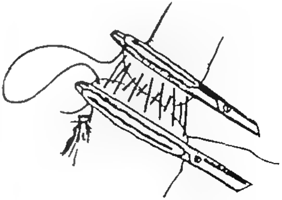
33 The distal end of the jejunum is brought up through a hole made in the mesocolon, ready for anastomosis with the oesophagus. Sometimes it is convenient to bring up the jejunal loop in front of the transverse colon. Care must be taken not to exert strong or sudden tension on its mesentery



The oesophago-jejunal anastomosis

The posterior sero-muscular layer

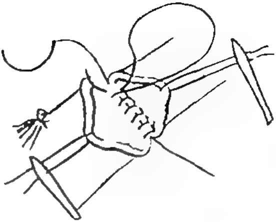
34 A continuous catgut suture is placed between the posterior layers of the approximated ends of the oesophagus and jejunum, taking the muscular layer of the former and the sero-muscular layer of the latter The threads may for convenience, be left loose and pulled up tight on completion of this layer



35

The posterior all-coats layer

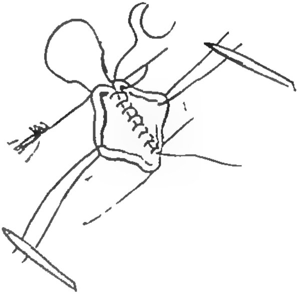
A continuous catgut suture passes through all the coats of the posterior layers of oesophagus and jejunum. Special care must be taken to include the oesophageal mucosa in each stitch. It is the practice in some clinics to use interrupted non-absorbable sutures for this layer and good results are also obtainable by this method.



36

The anterior all-coats layer

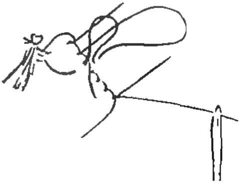
The posterior suture is continued round the anterior layers, a single Connell suture being used to turn the corner, apart from which the suture is of the simple over-and-over type, this being more haemostatic than the Connell suture.

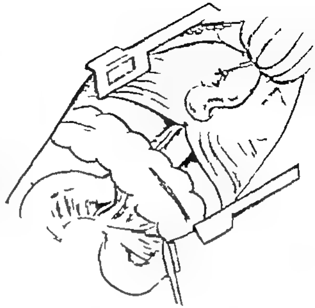


37

The anterior sero-muscular layer

The posterior sero-muscular suture is continued right round the anterior surface. The needle should enter the oesophagus about 0·5 cm. above the all coats suture line and come out almost at the suture line. On the jejunal side the needle should be inserted and withdrawn further from the "all coats" suture line, so that the net result will be to draw a fold of the mobile jejunal sero-muscularis up to the less mobile oesophagus and so cover the first suture line. A few additional sutures may be used to draw the sero-muscularis of the jejunum well up on to the oesophageal wall, as the oesophageal musculature is friable and not very mobile.

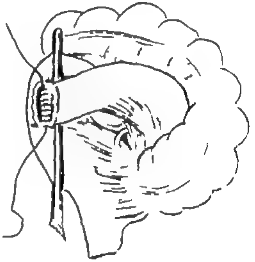




Repair of the diaphragm

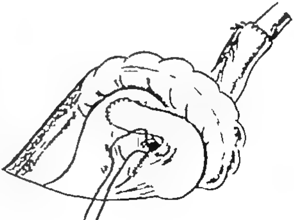
38 The diaphragm is sutured, being only loosely approximated round the jejunum

The jejunum is mainly supported by a good oesophago-jejunal anastomosis. It may be given additional support by 2 or 3 thread sutures between the jejunal mesentery and the margins of the diaphragmatic hiatus or adjacent tissue, but it may be dangerous to put holding stitches in the jejunum itself.



Repair of the proximal divided end of the jejunum

39 Jejunal continuity is re-established by an end-in-side anastomosis between the proximal cut end of the jejunum and the side of the Roux loop well below the mesocolon, using two layers of continuous catgut.



Prevention of internal herniation

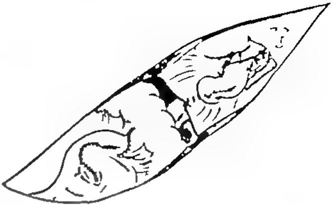
40 The hole in the mesentery and other artificial internal openings are repaired, and the edges of hole in the mesocolon approximated round the jejunal loop

The operation completed

41 The repair of the diaphragm is completed, and after instilling a little penicillin powder into the mediastinum the mediastinal pleura is partially drawn over the oesophageal anastomosis.

After final confirmation that all the loops are lying comfortably and that haemostasis has been secured, the chest and abdomen are closed in layers. It is usual to place an intercostal under water stab drain into the left pleural cavity.

If the pancreas has been transected a drain should be placed down its cut end. As there is incomplete separation between the abdominal and thoracic cavities, under water drainage must be applied to this abdominal drain also *or air may enter through it and pass up round the jejunal loop into the pleural cavity.*



LOCALIZED GROWTH OF THE CARDIA

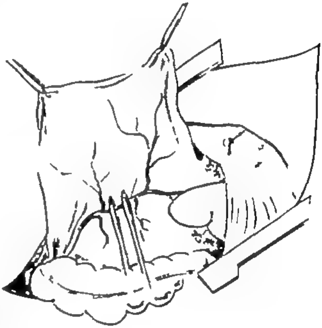
Radical "Upper Partial" Gastrectomy ("Oesophago-Gastrectomy")

The Approach is through a thoraco-abdominal incision as in a radical total gastrectomy (Illustrations 15 and 16).

Mobilization of the stomach

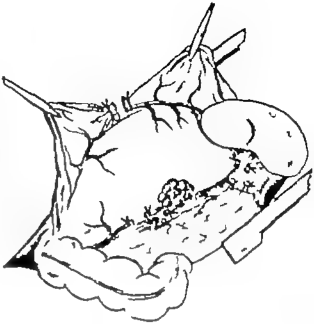
42 The great omentum is stripped off the colon and the greater curve mobilized from left to right as far as the antrum. At a suitable point, at least 6 cm below the growth and well below any glands, the gastro-epiploic arch is divided and an area of greater curve of antrum cleaned, the right gastro-epiploic artery being left intact.

The spleen is turned forward and the splenic pedicle divided. Any lymph nodes in the hilum are separated from the pancreatic tail.



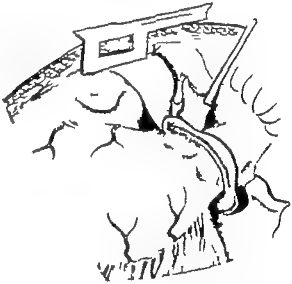
Preparation of the lesser curvature of the stomach

43 The lesser omentum is divided close to the liver and an area of lesser curve, again at least 6 cm. below the growth and any glands, is cleaned by dividing the junction of right and left gastric arteries, the right gastric artery being preserved.



Division of the left gastric pedicle

44 The left gastric artery and vein are dissected clean and divided separately near their origin, as described in Lower Partial Gastrectomy (Illustration 8) In addition to the artery and vein, a strong vagal branch (the coeliac branch of the posterior gastric nerve) and sympathetic fibres will be found in close proximity to the artery and will require division. The main lymphatic trunk passes anterior to the vein and if enlarged glands are present it is desirable to strip any adjacent glands from the upper border of the pancreas and remove them with the stomach.



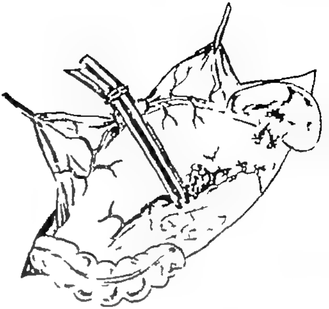
Mobilization of the growth and oesophagus

45 The growth is mobilized, a cuff of diaphragm being taken to ensure wide clearance of growth the upper stomach and the lower half of the oesophagus are mobilized as shown in Illustration 28 The loose mediastinal tissues from the level of the inferior pulmonary vein should be stripped down to be removed

46 with the growth. A branch from the thoracic aorta to the oesophagus usually requires ligature and division. At the end of the mobilization, the aorta should be well seen posteriorly the pericardium in front and the right mediastinal pleura on the right margin. Occasionally the tumour is adherent to the pleura and the right pleural cavity may be opened. Such an opening should be covered temporarily with a moist swab and later repaired if possible If it is not repaired, care must be taken to aspirate any blood from the right pleural cavity at the end of the operation. The level of oesophageal transection should be at least 4 cm. and preferably 6 cm. or more, above the upper palpable limit of the tumour

Resection and anastomosis

47 Long Payr's clamps are placed across the antrum. Stevenson's clamps are placed across the oesophagus at least 4 cm above the upper visible and palpable limit of the growth. The specimen is resected between the clamps.



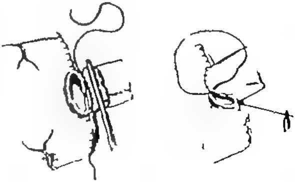
Kocher's mobilization of duodenum

48 The duodenum is mobilized by Kocher's method to allow easy approximation of the oesophagus and antrum.

The greater and lesser curves of the cut end of the stomach are closed by over-and-over stitching through all layers, leaving a central stoma of diameter slightly bigger than the oesophagus. Alternatively, the stoma may be left on the greater curve side of the cut end of the stomach, the lesser curve side being closed with two layers of catgut.

The oesophago-gastric anastomosis

49 The anastomosis commences as a seromuscular closure of the greater curve side of the stomach, which continues as a posterior seromuscular layer joining the oesophagus to the gastric stoma. The posterior all-coats layer is inserted and continued round anteriorly, care being taken to *include oesophageal mucosa in each stitch*. The anterior seromuscular layer commences at the lesser curve, and is continued across to the greater curvature. After completion of the anastomosis, penicillin powder is instilled into the mediastinum.



The operation completed

50 The diaphragm is drawn together loosely round the stomach remnant, and suture of diaphragm completed. In order to remove any tension from the anastomosis, the stomach remnant should be drawn up and fixed with interrupted sutures to the margins of the new diaphragmatic hiatus. Usually the pylorus lies opposite the new hiatus. The author (Tanner 1951) has long advocated the addition of pyloroplasty (or Rammstedt pylorotomy) after *upper* partial gastrectomy in order to prevent post-vagotomy stasis in the gastric remnant.

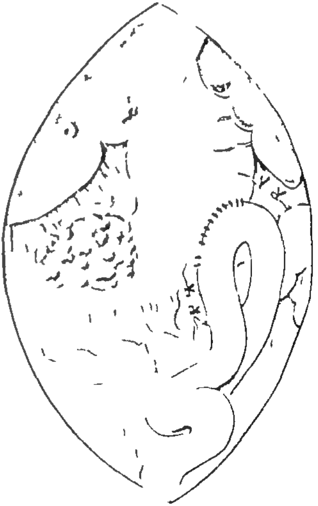
The chest and abdomen are closed in layers. An intercostal stab drain is inserted and connected to an underwater seal drainage bottle. The abdominal and thoracic parietes are repaired in layers.

PALLIATIVE PROCEDURES FOR CARCINOMA OF THE STOMACH

LOCALIZED GROWTH OF THE ANTRUM

High gastro-enterostomy

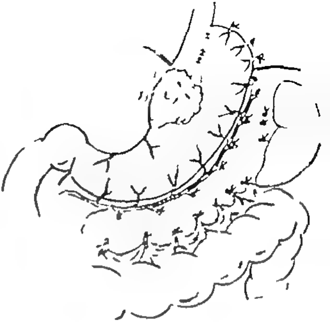
51 The simplest procedure namely an antecolic anterior gastro-enterostomy is preferable. The anastomosis is made to the greater curve of the stomach body because this part is not likely to be involved in the growth until very late. The efferent jejunal loop should be lower than the upper in order that gravity may assist drainage of the stomach. The afferent loop should be brought up under the splenic flexure of the colon.



LOCALIZED GROWTH OF THE CARDIA

Mobilization of greater curve with oesophago-gastric anastomosis

52 After division of the diaphragm the greater curve of the fundus and body of the stomach are mobilized by division of the vasa brevia and left gastro-epiploic vessels. The left gastric pedicle can be left intact The fundus is drawn up and anastomosed side-to-side to the oesophagus, using two layers of continuous catgut or interrupted non-absorbable sutures may be used.

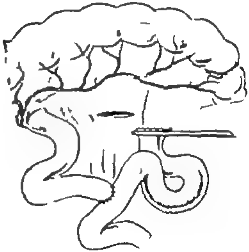


CARCINOMA OF THE CARDIA

Oesophago-jejunal Roux anastomosis by retro-pancreatic route favoured by author

53 An opening is made in the base of the mesocolon to the left of the inferior mesenteric vein and with a finger a tunnel is made upwards in front of the kidney and adrenal, but *behind* the pancreas and lesser sac of peritoneum until the diaphragm is reached. An incision is made in the latter

The Roux loop is prepared as shown in Illustration 81 drawn through this tunnel and anastomosed end-in-side to the oesophagus above the growth, in two layers.



THE OPERATION COMPLETED

54 The cut end of the proximal jejunum is united to the side of the jejunal loop well below the mesocolon, and any artificial openings through which strangulation may occur are repaired. A few interrupted fine sutures between the incision in the base of the mesocolon and the jejunum passing through will help to take the weight of the jejunum from the oesophago-jejunal anastomosis.

Although an abdomino-thoracic incision is required for this operation, it is unnecessary to divide the diaphragm up and into the oesophageal hiatus.

SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

Shock may follow any of these extensive operations, but can be minimized by avoiding blood loss, and by replacing blood which is lost.

It must be realized that in all these operations, as a result of oesophageal division, or of dissection round the cardia, the vagal fibres are completely divided. Therefore, some gastric retention and intestinal ileus may occur. To anticipate this, gastric suction must be rather more vigorous and prolonged than after simple gastrectomy for ulcer and intravenous drip infusion is always required. For the same reason, transient diarrhoea may occur and should be treated by a fluid diet and Sulphathalidine. Severe diarrhoea will, of course, necessitate large saline transfusion to repair the fluid and electrolyte depletion.

Apart from these considerations, the post-operative treatment for patients who have had a radical "lower partial" gastrectomy will be similar to that for patients who have had partial gastrectomy for peptic ulcer.

Post-operative feeding

For total and "upper partial" gastrectomy the after-care must be varied in view of the fact that the oesophageal anastomosis is less secure than a gastro-jejunal one.

In such cases intravenous fluid replacement, using mainly 0.18 per cent of saline and 5 per cent glucose, will be required for 4–5 days.

For the first day the tube in the jejunum or pyloric antrum, as the case may be, must be aspirated frequently. On the second day small quantities of sterile fluid—for example 1 ounce of glucose and saline solution can be introduced into the stomach remnant *via* the tube and if it is found to leave the stomach within half an hour, regular instillation of 1–3 ounces an hour can commence. Aspiration through the tube should always precede the introduction of a feed, or gastric atony may be overlooked and tension put on the oesophageal suture line.

On the fourth to the fifth day the patient can be fed with fluids orally and provided that there is no sign of ileus, the in-dwelling naso-gastric tube can be removed on the fifth day and the intravenous drip discontinued. Fluids or semi-solids only should be given for 10 days, and then solids can be taken in increasing quantities. By the end of 8 weeks, the patient should be on a near normal diet.

Post-operative care of the lungs in trans-thoracic operations

Immediately on return from the operating room the patient should be given a high concentration of oxygen using a B.L.B. mask or by the use of an oxygen tent for a few hours until the respirations are quiet and easy.

There is a tendency for excessive bronchial secretions to collect and so the patient must be encouraged to cough them up being aided by changes of posture by analgesics—Omnopon oxygen and carbon dioxide inhalations, steam inhalations. Failure to expel the secretions may lead to a purulent bronchitis or pulmonary collapse. If the latter complication occurs, the suitable antibiotics must be discovered by sputum culture and used and further efforts to extract the bronchial mucus made by the passage of an aspirating catheter into the bronchus either blindly or by bronchoscopy.

Care of the pleural cavity

Some bleeding into the pleural cavity is inevitable and so blood escapes *via* the drain. After about 36 hours, respiratory excursions are no longer evident in the fluid level in the drain bottle and the drainage tube can be removed. The following day a chest radiograph is taken, and if there is evidence of any pleural effusion, it should be aspirated.

Post-operative chemotherapy

This is required in all of these transthoracic resections—penicillin and streptomycin usually being given for least 5 days. This will diminish the incidence of infective complications, pneumonia, bronchitis, lung abscess empyema, mediastinitis, peritonitis and wound infections.

Phlebo-thrombotic and embolic complication may occur and may be minimized by early leg and [illegible] exercises, early ambulation and avoidance of infection at the site of intravenous infusion.

Necrosis of tissue in the region of the oesophago-jejunal or oesophago-gastric anastomosis followed by suture leakage is the surgical complication most to be feared. If diagnosed, the site must be drained by a transth[illegible] drainage tube and also by aspiration of the site of leakage *via* a naso-oesophageal tube. If necrosis is extensive, the patient must be made fit by intravenous blood plasma and saline infusions, and a second operation to bring up a jejunal loop or to bring the existing jejunal loop higher will have to be undertaken.

[*The illustrations for this Chapter on Gastrectomy for Cancer were drawn by Mrs. J. Mace.*]

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VAGOTOMY

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PRE-OPERATIVE

Indications

Complete division of both vagus nerves and all their branches at the level of the diaphragm abolishes the psychic phase of gastric secretion, decreases the muscle tone of the stomach and changes the functions of the duodenum, small intestine, gall bladder and pancreas in a way which is not yet fully understood. It is not surprising therefo that the indications for this operation are controversial. The available evidence indicates that vagotomy is th operation of choice for gastro-jejunal ulceration following an adequate gastric resection. A few surgeons recom mend it in combination with a gastro-jejunostomy or a limited gastric resection for the treatment of duoden ulceration. It has been used and later abandoned as a treatment for a variety of other conditions, including ulcerativ colitis, various post-gastrectomy syndromes and chronic pancreatitis.

Special contra-indications

Vagotomy alone without some form of drainage procedure such as a gastro-enterostomy gives unsatisfactory results because the stomach wall loses its tone and gastric stasis develops. Vagotomy should not be performed c patients with both gastric and duodenal ulceration the duodenal ulcer may heal but the gastric ulcer often remains. Some patients with a gastro-jejunal ulcer develop a gastro-jejuno-colic fistula after a vagotomy this is particularly likely to occur if the colon is closely adherent to the ulcer base in such patients a resection is preferable In th opinion of many surgeons vagotomy is an unsatisfactory treatment for ulceration following the Billroth I form o gastric resection because the loss of muscle tone and fibrosis as the ulcer heals may lead to gastric retention.

Special pre-operative preparation

It is important that the patient should have a small gastric aspiration tube in position during the operation because this assists identification of the oesophagus.

Anaesthesia

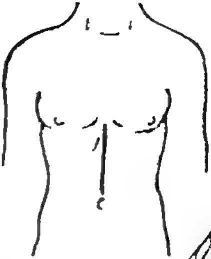
General anaesthesia is satisfactory When the abdominal approach is used adequate muscle relaxation is important.

Position of the patient

The usual position with the patient flat on his back is satisfactory for the abdominal approach. In difficult cases may occasionally be advisable to hyperextend the lower dorsal spine by raising the gall bladder bridge or breaking the table If the transthoracic approach is used the patient should be placed in the lateral position with the righ side on the table and the left lower chest exposed.

THE OPERATION

ABDOMINAL APPROACH

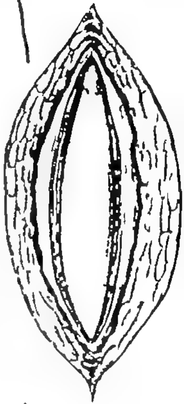


The incision

1 In nearly every case the abdominal approach is preferable because the reason for performing the operation will be an intra-abdominal abnormality and a full abdominal exploration should be carried out as a first step.

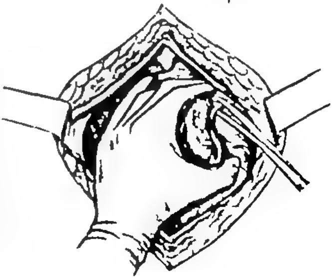
Both a midline upper abdominal and a left upper paramedian incision are satisfactory. Either should be continued on to the chest wall and the abdominal wall incised to the apex of the triangle between the xiphoid process and the costal margin. If necessary the xiphoid process can be removed.

2 The abdominal contents are now examined and if the surgeon decides to perform a vagotomy the oesophageal hiatus is exposed.



Mobilization of the left lobe of the liver

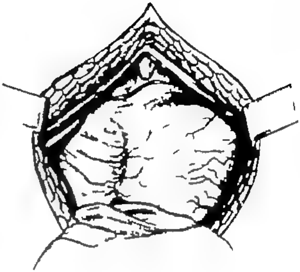
3 To mobilize the left lobe of the liver the surgeon places his left hand round the apex of this lobe and displaces it downwards and to the right; at the same time his assistant inserts a retractor in the left upper corner of the wound. Most surgeons find that wide bladed deep retractors are necessary throughout the principal stages of this operation. The left triangular ligament of the liver now comes into view and this is divided with scissors close to the liver and throughout its whole length starting at the free left margin; this ligament is avascular and splits at its right extremity into two peritoneal layers which should each be divided for about 1 inch (3 cm) of their independent course.



4

Exposure of the oesophageal hiatus

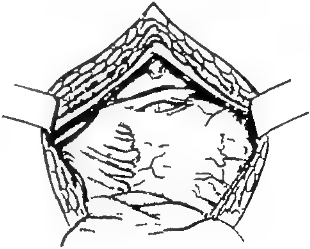
The whole of the left lobe of the liver is now placed in the right side of the abdomen and held there by a wide-bladed deep retractor over a large swab. This will expose the oesophageal hiatus. Palpation of the gastric aspiration tube in the oesophagus provides a valuable check to confirm that it is the oesophageal hiatus which has been exposed. Gentle retraction on the stomach in a downward direction will place the oesophagus under tension and in an obese patient will help to bring this region into view



5

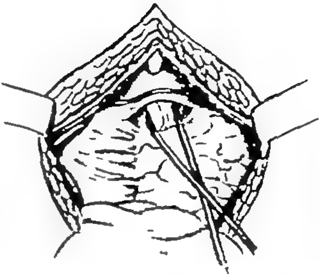
Incision of the peritoneum over the oesophagus

A fairly large vein, the left inferior phrenic, passes across the under surface of the diaphragm just anterior to the oesophageal hiatus; the peritoneum over the oesophagus should be incised transversely with scissors about 1 inch (3 cm.) below this vein so that it can be sutured at the end of the operation with less risk of pricking it with a needle. When the peritoneum has been opened the oesophagus with the left vagus nerve usually lying on its surface comes into view



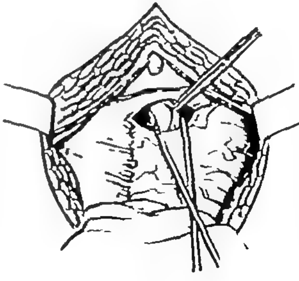
Mobilization of the oesophagus

6 The first step is to pass a finger beside the oesophagus through the oesophageal hiatus of the diaphragm into the thorax. With this finger the oesophageal hiatus is slightly stretched and a second finger passed through. With these two fingers the oesophagus is mobilized. It is important to carry out this mobilization above the diaphragm where it can be performed in a well-defined avascular tissue plane; below the diaphragm there is no such plane and several small vessels lie close to the oesophagus and cardiac end of the stomach. During this procedure the surgeon can feel the vagus nerves as tense, tough cords and a mental note of their position at this stage serves to assist in their visual identification later on. At the conclusion of this manoeuvre a medium-sized rubber tube is passed round the oesophagus and the two ends brought out of the wound.



Resection of the left vagus nerve

7 The left vagus nerve usually lies on the anterior surface of the oesophagus; it should be mobilized for a distance of about 3 inches (7 cm.) and this segment resected. Light *traction on the rubber tube serves to draw the* oesophagus forwards and this, combined with the fact that it puts the fibres under tension, aids identification of the vagi. Sometimes this nerve lies on the right, sometimes on the left and very occasionally on the posterior wall of the oesophagus; it is of value to remember that in about [illegible] per cent of patients all the fibres of the left vagus nerve will be mobilized with the oesophagus. The left vagus nerve at this level usually consists of a nerve plexus which comes together to form one main trunk at the level of the oesophageal hiatus in the diaphragm and then spreads out again on the stomach. In addition, in most patients two or more additional small nerve fibres exist; these must be looked for and a portion of each resected; it is easier to feel these thread-like cords than to see them.



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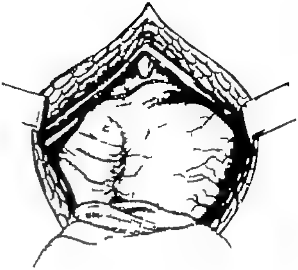

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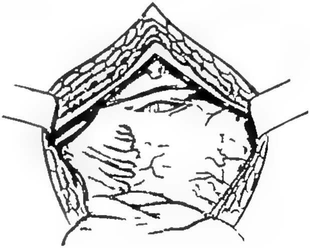

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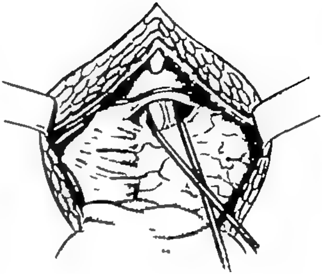
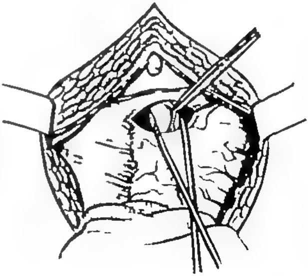


Resection of the left vagus nerve

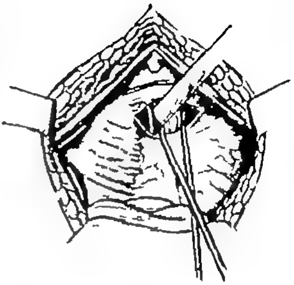
7 The left vagus nerve usually lies on the anterior surface of the oesophagus; it should be mobilized for a distance of about 3 inches (8 cm.) and this segment resected. Light traction on the rubber tube serves to draw the oesophagus forwards and this, combined with the fact that it puts the fibres under tension, aids identification of the vagi. Sometimes this nerve lies on the right, sometimes on the left and very occasionally on the posterior wall of the oesophagus; it is of value to remember that in about 90 per cent of patients all the fibres of the left vagus nerve will be mobilized with the oesophagus. The left vagus nerve at this level usually consists of a nerve plexus which comes together to form one main trunk at the level of the oesophageal hiatus in the diaphragm and then spreads out again on the stomach. In addition, in most patients two or more additional small nerve fibres exist; these must be looked for and a portion of each resected; it is easier to feel these thread-like cords than to see them.



Resection of the right vagus nerve

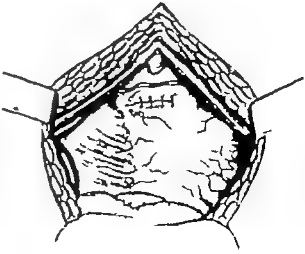
8 The right vagus nerve differs from the left in that it is rarely mobilized with the oesophagus. It remains behind on the right side of the oesophageal bed, often covered by the inner margin of the right crus of the diaphragm. Realization of this fact is of the utmost importance and failure to find this nerve, the larger of the two vagi at this level, accounts for many incomplete operations. The right vagus nerve which should have been felt and located during the mobilization of the oesophagus is brought into view by putting a narrow-bladed deep retractor beside the oesophagus and displacing it to the left. This may demonstrate the nerve passing obliquely from right to left on its way to the posterior wall of the stomach. If the nerve cannot be seen it should be felt for with the finger and then freed by blunt dissection for a sufficient distance to permit the removal of about 3 inches.

It is difficult to obtain a complete section of the vagus nerves. Realization of the fact that the anatomical position of the nerves varies considerably and a careful search for extra fibres will reduce the number of incomplete operations.



Closing the peritoneum over the oesophageal hiatus

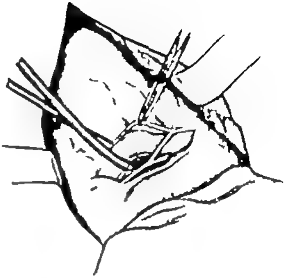
9 The operation of vagotomy is now completed by closing the incision in the peritoneum over the oesophageal hiatus. The left triangular ligament of the liver is not replaced. It is now advisable to perform some form of drainage operation on the stomach such as a gastro-jejunostomy or pylorectomy if one is not *operating for an anastomotic ulcer*



THE THORACIC APPROACH

10 An indication for the transthoracic approach is gastro-jejunal ulceration following an adequate partial gastrectomy and which has persisted after a vagotomy in these circumstances a complete denervation may be obtained with a thoracic incision

The approach is made *via* the left pleural cavity through a lower thoracotomy incision (see surgery of access) The lung should be retracted upwards and the mediastinal pleura opened by a longitudinal incision in the pulmonary ligament this will expose the oesophagus. About $2\frac{1}{2}$ inches (6 5 cm) of oesophagus should be mobilized by finger dissection and a rubber tube passed round it. The main trunks and lesser filaments of the right and left vagus nerves are now identified in the way already described and about 2 inches (5 cm) resected from each Those on the right side of the oesophagus can be reached by retracting this structure to the left with the rubber tube



SPECIAL POST-OPERATIVE CARE AND COMPLICATIONS

This differs from that after any other upper abdominal operation in only one detail Patients with a complete vagotomy have an atonic stomach. It is wise therefore to leave an indwelling nasal aspiration tube in the stomach of every patient for a longer period than is usual after other gastric operations, and to keep the stomach empty by intermittent suction until it has regained some of its muscle tone This is a wise step in the post-operative care of those patients who have had a previous gastro-jejunal anastomosis as well as those with a recent anastomosis.

Diarrhoea

A small proportion of patients suffer from severe diarrhoea after a complete vagotomy This complication is difficult to treat and may persist for months after the operation.

Gastric retention

This most distressing complication follows a complete vagotomy which has not been combined with a gastric drainage operation. These patients belch up large quantities of foul wind. The treatment is to perform a partial gastrectomy or a gastro-enterostomy

Pseudo-achalasia of the cardia

A condition both clinically and radiologically resembling achalasia of the cardia may occur after vagotomy It is transitory Treatment is by reassurance or occasionally dilatation.

[*The illustrations for this Chapter on Vagotomy were drawn by Mr J Wheldon*]

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